FARM KNOWLEDGE

SOILS AND CROPS

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THE FARMER holds in his hands the destiny of the soil and the bounty of its crops. For the way a soil is handled, fed, and cared for determines the size and value of its crops; and the way those crops are chosen, arranged, and disposed of, determines the life and producing power of the soil. How many of us measure up to this opportunity, this responsibility?

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FARM KNOWLEDGE

A Complete Manual of Successful Farming Written by Recognized Authorities in All Parts of the Country; Based on Sound Principles and the Actual Experience of Real Farmers—"The Farmer's Own Cyclopedia"

EDITED BY
E. L. D. SEYMOUR, B. S. A.

IN FOUR VOLUMES

VOLUME II. SOILS AND CROPS

The Principles and Practices of the Management of Soils and the Use of Fertilizers; Farming Conditions and Systems in America; Farm Crops and How to Grow, Improve, and Protect Them

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Revised Edition, 1919

FARM KNOWLEDGE

VOLUME II. SOILS AND CROPS

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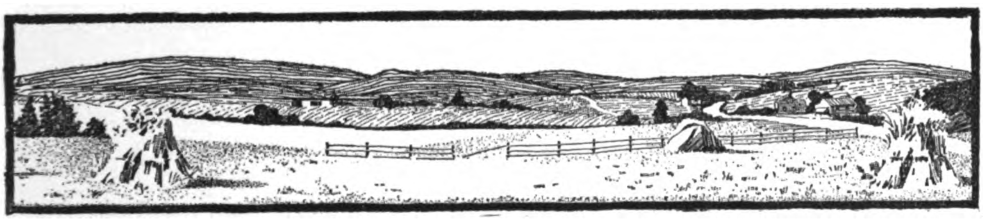

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A List of the Men Who Have Written This Volume, Together With the Subjects on Which They Have Written, and the Pages on Which Their Contributions Appear

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(*Continued*)

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FARM KNOWLEDGE

FARM KNOWLEDGE

VOLUME II—PART I

Soils and Soil Management

THIS volume of "Farm Knowledge" deals with three main subjects: (1) soil and its management; (2) crops and their management; and (3) systems of farming in the United States, representing, of course, the various combinations of (1) and (2) that farmers are actually practising. Under the first of these general headings are discussed also the manures, fertilizers, and other materials used in the treatment of soils. Under the second large heading are treated: (a) the actual methods of raising farm crops of all kinds; (b) the means by which crops may be improved; and (c) the dangers and injuries to which they are subject and the measures with which they may be conquered or controlled. Systems of farming are treated from two aspects: (1) geographically, to show the relation of conditions in different parts of the country to the practices that have proved successful there; and (2) descriptively, to explain the principles that govern the successful development of each particular system.

The story of the soil is a many-sided one. It is a history, ages old, of how rocks and mountains were formed, developed, changed, worn down, and built up again; this special phase forms the science of *Geology* (Volume 4, Chapter 18). It is a mysterious tale of wonderful materials and living organisms and the changes they bring about; this is the science of *Soil Chemistry* (Volume 4, Chapter 17). It is a mighty tale of powerful forces, of long, slow changes, of the effects of heat and cold and light and pressure; these fall within the science of *Soil Physics* (Volume 4, Chapter 16). It is the story of the invention and perfection of splendid tools and the work they do in fitting and modifying the soil to meet man's needs; these tools and their influences are discussed in Volume 3 (Chapter 10). It is the tale of man's cleverness and industry in modifying conditions of soil moisture such as prevent the greatest and best use of the land; these activities—Drainage and Irrigation—are discussed in Volume 3 (Chapters 20 and 21).

But aside from all these discussions of specialized lines of soil care, and of the application of soil characters to particular conditions, there must be, to keep the subject sharp and clear in our minds, one complete review of the *practical side of soil management.* It is this systematic, orderly survey to which the following eight chapters are given up. They supply a foundation for, and an introduction to, further and deeper study of a subject about which our greatest scientists and our most successful farmers have much yet to learn.

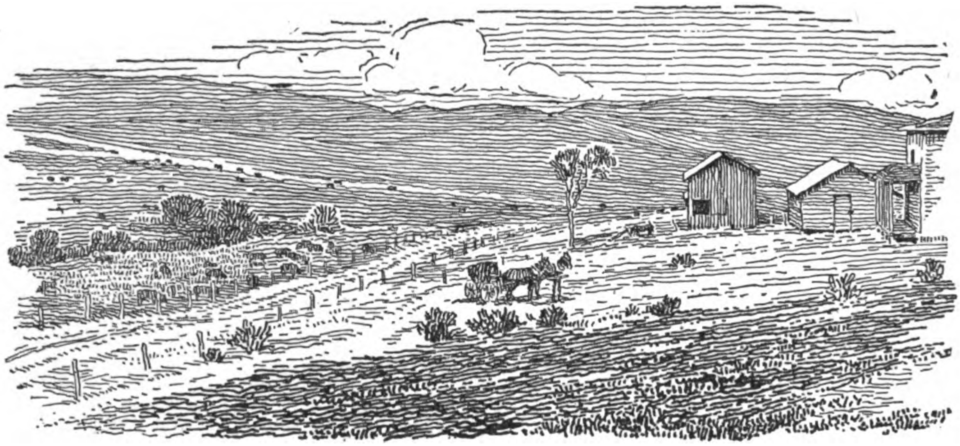


FIG. 1. Scenery and lay of the land typical of a loess (wind-blown) soil formation, such as is found in parts of the corn belt (See Chapter 11)

The really successful farmer is he who thinks about his soil as he plows it; who looks back beyond the day or the year when he first raised a crop on it, and pictures its development and previous treatment at the hands of other men; who looks ahead, beyond this year's harvest and next, with the desire and firm intention of making for its permanent betterment.

Understood and well-treated, the soil becomes the farmer's faithful servant, his friend, his ally, his banker, the cornerstone of his success. Neglected and abused, it rebels and becomes, perhaps, his master, but at all events his enemy, his creditor, the false support through which he plunges down into failure. The lesson clearly is "to know thy soil as thou knowest thyself."—EDITOR.

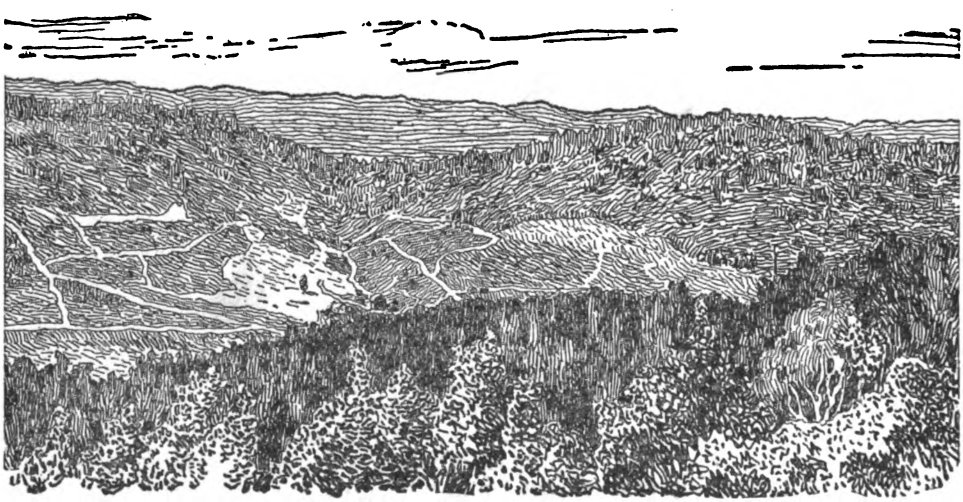


FIG. 2. Mountain country of the North Atlantic States (Chapter 10) south of the glacier line, where the hilltops have not been planed off nor the valleys filled by the action of the ice sheet. Compare Fig. 103

CHAPTER 1

Farm Soils: What They Are and How to Know Them

By Elmer O. Fippin, *Director, Agricultural Bureau of the Lime Association and previously, from* 1913 to 1919, *Extension Professor of Soils in the Cornell University College of Agriculture. He was born and reared on an Ohio farm and graduated from the College of Agriculture of that state. From* 1900 *to* 1906 *he was engaged in soil survey work for the U. S. Dept. of Agriculture in Maryland, Michigan, Iowa, Illinois, Missouri, Florida, Georgia, Connecticut, Massachusetts, New York, and North Dakota. Then he was detailed by the Department to teach Soil Technology at Cornell, becoming, first Assistant and later, full Professor. He lives on and operates a fruit and poultry farm, so knows the practical as well as the scientific problems of soil management. He has written two text books on soils and a number of bulletins, soil survey reports, and other papers.*

THE soil is that layer of the earth's surface in which plants grow. It includes every square foot of such surface whether the soil is deep or shallow, productive or unproductive, fine or coarse, light colored or dark colored, level or hilly. On every exposed surface nature sooner or later establishes plants that live out the cycle of their lives. If the soil is meager then only the smallest plants can live—moss, lichens, or even bacteria; on the barest rock cliff these bacteria—simple one-celled plants—may be found. When the soil is deep, moist, and rich, large vigorous plants thrive.

The soil is everywhere. Its quality, that is, its capacity to produce plants, varies. Where large, luxuriant plants grow, the soil is said to be of good quality; where only small, weak plants grow it is said to be of poor quality. This difference may be traced to definite causes that affect the soil's capacity to produce plants. If it is thin or coarse, it probably is dry and plants shrivel up from the lack of moisture if, indeed, they make any real start. Or it may be so compact, dense, and fine that the roots of plants cannot penetrate far into the surface layer to secure the food and moisture required.

Land is another term applied loosely to areas of soil without respect to its productive capacity. Sometimes it is said that a piece of land has no soil if the surface layer of earth has been recently removed, or if it is mostly bare rock or coarse stone. This statement is, of course, not strictly true since the surface material that remains may still produce plants although they may be but small, weak ones.

All soils may be improved. The bottom of a clay pit may be worked up and doctored into a productive soil. A bare rock surface or a pile of boulders may be improved as soil by being broken up, and by the addition of fine soil from another place, compost, fertilizer, and other materials. Whether it is profitable or desirable to improve a particular area of soil depends on the purpose for which it is to be used and the plans of the person concerned. While it is possible to improve any soil, it is often not profitable; and usually the practice rests on a dollars and cents basis. The question often is: Is it more profitable to improve this piece of land I have, considering the expense of all the different treatments necessary, or will it be more profitable to secure another and better piece of land that does not require so much treatment? Many persons make the mistake of trying to improve a very poor soil when they would do better to look for an area of better soil.

Soil Characters and Materials

Soil and subsoil. The entire surface layer of the earth is soil. But look at any road cut, ditch bank, cellar bank, or other section or exposed edge of the soil and you will usually notice variations in its appearance and character. The surface few inches are likely to be darker in color than the lower part. There may be a banded effect caused by a very dark top layer, next quite a light colored layer and toward the bottom a darker, or even a still lighter colored layer.

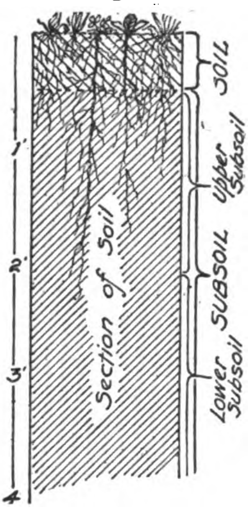


FIG. 3. (This and Figs. 4, 5, 6, 9, and 10 from Cornell Reading Course Bulletins).

When considering the soil in detail, the word *soil* or *topsoil* is applied to only this surface dark colored layer, while all below is the subsoil. For further distinction the subsoil may be divided into upper subsoil and lower subsoil.

Depth of soil. There is no limit to the depth to which the subsoil may extend. It is defined as the depth to which plants use the soil. Here, many persons make a common mistake. They think of plants as rooting very shallow—in the surface foot or two of soil. On the contrary, plants if given a fair chance will root much deeper, depending, of course, on the moisture and drainage conditions. Ordinary farm crops, such as timothy, corn, oats, clover, cotton, rice, wheat, and fruit trees in fairly well-drained soils send their roots from 3 to 5 feet into the soil. Even small plants such as Kentucky blue grass, onions, and lettuce may send them 2 and 3 feet deep. On the other hand, in those regions where the surface soil at times becomes very dry while the subsoil is moist and well drained, the roots of crops and trees reach deep into the subsoil—6 feet, 10, 20, 50 feet. There is even a record of an alfalfa root that penetrated more than 75 feet into the earth! These extremely deep-rooting habits usually are found in arid and semi-arid regions where the rain and irrigation water are stored deep. However, the bulk of the roots of crops, especially in humid regions, are found in the surface foot of soil, where a dense, fine mass of roots is usually developed. This is particularly noticeable in grass plants. Experiments show that 75 per cent or more of the total bulk of roots of the grass and grain crops is found less than a foot below the surface. This does not lessen the importance of the roots that penetrate below that depth; in fact, in critical times, such as dry spells, these become the vital supports of the crop.

The soil at close range. Looked at more closely, the soil is seen to be a mixture of powdered rock and partially decayed remains of plants and animals. The plant and animal material, commonly called *organic matter* and in part *humus* (p. 18), has a dark brown or black color and staihs the rock part of the soil a correspondingly dark color. Since more organic material is added to the topsoil than to the subsoil, the former is more stained and hence a darker color. This color difference is one of the more prominent distinctions between the soil and subsoil. There are also differences in the fineness and compactness of the two layers. The topsoil is usually more open, friable and porous. On the whole, it is in a better physical condition than the subsoil.

But the rock particles and the decayed plant and animal material are merely its framework—its skeleton—vitally important, of course, but only in their relation to its other parts. Remember that a soil is good in proportion to its capacity to produce crops. Crop production—plant growth—is the result of a combination of materials and processes. Plants must have food, moisture, air or oxygen, heat, and usually light, besides a mechanical support or place to develop. Every one of these essential conditions for plant growth, except the light, is affected—in fact

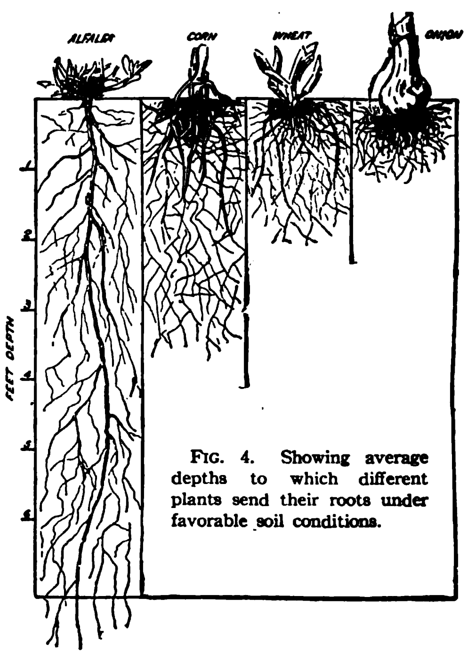


FIG. 4. Showing average depths to which different plants send their roots under favorable soil conditions.

determined—by the properties of the soil. The color and slope even have some effect on the light through their influence on reflection and shadow.

These essentials for plant growth—food, moisture, heat, and the rest—are made available to the plant through the rocky and organic framework of the soil. If all are well supplied by the soil and the climate of the region, a particular plant or group of plants makes a large growth and the soil is said to be fertile or productive. If, on the other hand, one or more of the essential conditions is lacking or poorly adjusted to the others, the plant is able to make only a small growth and the soil is termed unproductive.

Thus the consideration of the productive capacity of the soil involves the practical question of supplying through it the materials and the conditions required by the crop. In proportion as these requirements and me ansto provide them through the soil are understood, we have intelligent soil management. Anything short of that knowledge and practice is merely the operation of the law of chance, at best a very uncertain rule to go by.

It is the aim of this and later chapters on the soil to discuss the materials and processes of the soil in their relation to crop production in order to supply the desired rational basis for soil management.

How Soil Is Formed

Doubtless, many farmers and others have wondered why a particular field had such a soil or variety of soil. In one place may be gravel and in another clay; in one place great depth and in another little or no depth; in one place a black soil and in another place a red, yellow, or light-colored soil; in one place a very fertile soil and in the next square rod or the next field a very infertile soil. It is impossible to understand fully the character of any soil area without knowing something about the way it was formed.

Viewed as a world-wide material, the soil is merely a part of the waste, the scrap, the splinters and shavings of earth's change and progress. The earth is a globe of stone solidified only in its outer shell. This stone shell which everywhere underlies the blanket of pulverized rock material of which the upper part is the soil, is undergoing constant but very slow change. The forces of nature—pressure, heat, frost, water, ice, and wind—as well as the processes of plants and animals—are continually at work on the rock shell, breaking up its surface, changing its composition and moving its material about. The soil is the latest waste of that process. Observe a rushing mountain rill or a flooded river after a heavy rain and note the mass of fine rock material that is carried and rolled along by the current, and you have a good illustration of one of the ways in which rocks are ground up

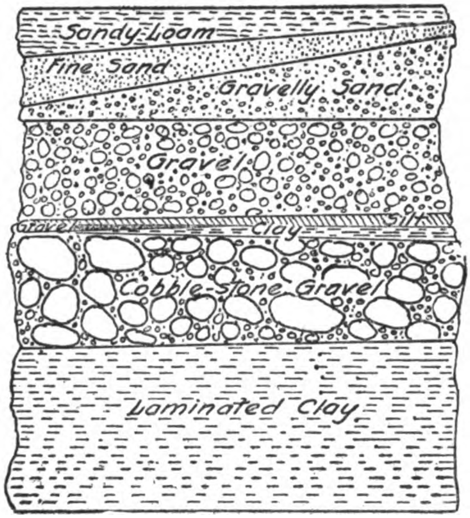


FIG. 5. Section through a soil stratified (that is, laid down in layers) by the sorting action of water

and their chips or waste carried to a new resting place.

Along every brook, creek, and river bed is spread a ribbon of this rock-flour laid down as "mud," sand, gravel, or stone, according to the speed of flow of the water. Rapid-flowing water carries material of all sizes, even up to boulders, and deposits or leaves behind only the coarsest. As the stream reaches lower levels and runs less swiftly it drops more of its load—always the coarsest material—until on the broad, flat river plain only the finest sediments remain to be deposited. These form the fine, uniform river and creek bottoms that make up so much of the most fertile farm land of the world. The Nile Valley, the valley of the Euphrates and Tigris—perhaps the Garden of Eden of the Bible, the valleys of the Rhine, the Danube, and the Seine in Europe, and of our own American Mississippi River system with all its large tributaries, all these are notable examples of soils carried and deposited by the flow of water from the higher land to the lower areas. Rocks are cut away by these flowing waters which, more than any other force, are responsible for the intricate pattern of valleys that form most of our landscape. Every exposed surface of rock gives up its toll of material to the passing stream. Millions upon millions of tons of rock material are moved by every rain storm. Rock material once carried a little way is again picked up and carried until the force of the current is reduced; and as it is moved, so also is it rubbed and worn down constantly smaller and smaller.

The sorting action of water. A very important action of water is the sorting of the

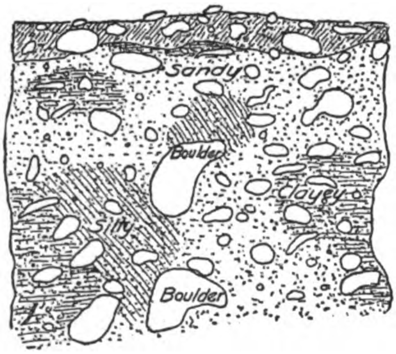


FIG. 6. Section through a glacial till soil showing the mixing of boulders and fine earth

material it handles. The boulders are left near their place of origin. From the rest of the mass carried, the gravel, the different grades of sand, the flour-like silt and finally the fine plastic clay are sorted, each in its turn, and laid down each with its kind. Whether these different materials form successive layers or broad, deep areas depends on the size, velocity, and permanency of the flow. Fitful streams form soils of varied texture such as are seen in the small creek bottoms that drain higher hills. Every rain makes of the stream a raging torrent that over-reaches its banks and leaves only gravel and stone in its main course. As it falls and slows up, the fine sediment is laid down on, or by the side of, the coarse. The result is a changeable soil.

But in the broad, flat river bottom where the current never flows more than 2 or 3 miles an hour and gradually slows down to perhaps still water in back pools, no coarse material is found, only fine sand, silt, and clay. The broad delta of the lower Mississippi River is one of the best examples of this latter process.

The ocean and lakes are another aspect of the action of water. The lapping of the waves and the swirl and flow of the shore currents have done an immense amount of soil formation, developing plains, areas of gravel, and clay. The border of every continent and of nearly every lake illustrates this. The broad, undulating and gently sloping plains of the Atlantic and Gulf coasts, the plains of France, the flat interior of much of Russia and many other parts of the world point to the shore work of the ocean and lakes.

Ice as a soil former. Ice comes next after water as a soil-forming agency. A large part of the best farming regions of the world are due to the ice action. This does not mean the peaceable masses of ice familiar to us as the winter covering of streams and lakes; their influence has been relatively unimportant. The great soil-forming force has been glacial ice. From a study of glaciers, geologists have found that similar masses of ice once pressed down from the polar regions over vast areas of country. More than half of the North American, European, and Asiatic continents have at some time been covered by these vast slow-moving and long-staying snow and ice fields. In this country the ice reached to a line that roughly passes near the cities of New York, Cincinnati, St. Louis, Kansas City, Omaha, and Bismarck, and again sagged south in the State of Washington. This ice reached a depth of several thousand feet. It exerted a tremendous grinding action and planed off the smaller heights and gouged deeper the valleys in its course. The entire soil covering of the rocks was swept away and carried along by it. Rocks were broken, ground up and made into new soil material to be finally dropped by the ice where it melted, perhaps hundreds of miles to the southward.

This general process accounts for the boulder-strewn upland soils of all the country extending from Maine to the State of Washington and reaching south in the Mississippi Valley as far as St. Louis.

Naturally, ice did not sort its soil material as does water, and glacial soil is therefore a mixed-up, unarranged mass of boulders and fine earth. Cross valleys were filled. Exposed rock points were brushed bare and left almost free of any soil covering. The harder the rocks acted upon, the more stony is the resulting soil.

Coupled with the direct effect of the ice was the sorting, moving, and re-arranging action of the water that came from the melting of the ice on its surface and at its lower edge, which formed rivers, pools, and even great lakes. The irregular surface of the land, the numerous lakes and ponds, swamp holes and poorly drained areas throughout the upper part of the northern continents as illustrated in New York, Michigan, and Minnesota are the result of this glacial ice action.

The kind of rock affects the soil. The kind of rock acted on by the water, ice, or other force also has an important effect on the character of the resulting soil. Any rock naturally rich in lime—especially limestone and limey sandstones and shale—is likely to be beneficial wherever it enters into a soil. The rock in any soil may have been carried long distances from its original site by either water or ice. In this case the soil is called a "transported" one.

A sure sign of the action of water in forming soil is the smooth and rounded surfaces of the gravel and boulders it has carried. The sorting and banding of the soil material in layers of clay, silt, sand, and gravel is also proof of water action. The rock material carried by ice is not so smooth and rounded in outline but it has generally been considerably smoothed and scratched and the sharp angles rounded off.

Some persons will be surprised when they

apply these statements to soils with which they are familiar. Their land may be high up on the hills or far out in the centre of a great level area; but if gravel and sand and fine clay are there, they form proof that water once was there. The typical glacial boulders indicate the far reach of the glacial ice, so far, indeed, that it is hard for us now to picture in our minds the conditions when those soils were formed. But as dripping leaves and wet earth in the morning are the proof of rain during the night, so these earth signs are equally good proof of the magnificent processes that have been at work on our own farms and in our own back yards. Knowledge of these things gives us a new respect for the common soil beneath our feet and the pebble we would cast aside.

Other soil-forming forces. The forces of water and ice are vigorous and often spectacular. Working ahead of and along with them are many agencies much quieter and less impressive, but that, nevertheless, have helped greatly in soil formation.

Every rock ledge, every boulder and pebble is continually set upon by thousands of instances of such forces: for example, the beating of the rain, the dissolving action of water, the splitting force of frost, the prying force of plant roots, the burrowing and scratching of animals, and finally the blasts of wind armed with particles of sand. "Solid as a rock" is a phrase commonly used to express permanency; yet even rock is not permanent. It is continually weakening and crumbling. The rock ridge of this age becomes the rounded plain of a future age. The rocks have literally rotted away. They have softened and broken down, and the present deep layer of soil is but the small residue of a once towering hill. Limestone is eaten away by moisture into the form of caverns so that each foot of limestone soil represents from 20 to more than 90 feet of solid limestone rock. Granitic rocks are not so largely lost in the soil-forming process, yet each foot of the resulting soil may represent 2 feet or more of the original rock (Fig. 7).

Soils that are thus formed without being mixed or carried from place to place are *residual* soils, and the middle part of the American Continent outside of the Great Valley region has many such. The famous Kentucky bluegrass soils are residual from limestone; the red clays of western Virginia and the Carolinas are the residue from granite and gneiss rocks.

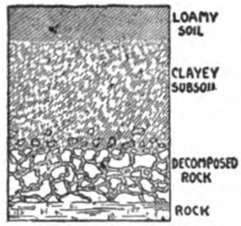


Fig. 7. Section through a typical residual soil, formed by the decay of underlying rock.

Plants and animals as soil material. The rock part of the soil is the most ancient and permanent; the part derived from plants and animals is more recent and temporary. The organic remains are products of years the rock material is the product of the ages. The longer a soil has been formed the less organic matter it is likely to contain. This organic matter is called *humus;* a good illustration is the black leaf mold found in hardwood forests. Any condition that favors the growth of plants and the accumulation and preservation of their remains makes the soil richer in this humus. Where shallow lakes and ponds have occurred great amounts of organic matter have often collected to form peat and muck soils. They are preserved by the wet conditions. Under these deposits there are also frequently formed soft deposits of lime carbonate commonly called marl. This is really a soft limestone and may be just as pure a lime material as the hard rock form.

Organic matter is a useful part of the soil. The organic material is just as important a part of the soil as the mineral material. One aids the other in making a fertile soil, the rock furnishing the mineral elements of plant-food and the organic matter supplying equally essential and usually more critical elements, particularly nitrogen. Each balances up the physical properties of the other, organic matter keeping the mineral soil loose, open and in good tilth; and mineral soil giving muck and peat a better body and a better moisture relation. From 3 per cent to as much as 50 per cent of organic matter and humus adds to the productive capacity of any mineral soil. Less than 3 per cent, especially in the topsoil, is usually a cause of poor crops; more than 50 per cent is without value

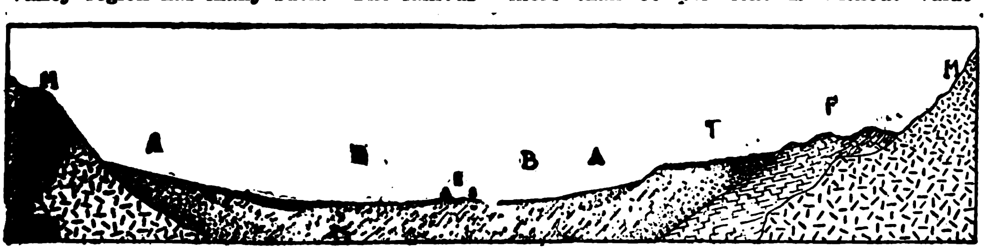


Fig. 8. Section of a typical (California) valley: M mountains washed bare of soil; F foothills with residual soil; T terrace formed by erosion of soil washed from mountain; A alluvial slopes; B flood plains; R river with built-up banks (S—S).

and, for most crops, is likely to be injurious. The best proportion of organic matter depends largely upon the kind of crop to be grown. Forage and vegetable crops require the most; grain and fruit crops the least.

Some Properties of Soil

Size. The size of the soil particles determines its texture or textural property and very largely its ease of working, its capacity to hold moisture, and the kind of crops to which it is suited.

Clay. If the particles making up any soil were sorted out into groups arranged according to size, many sizes would be represented. There would be some particles so fine that they could not be seen even with a powerful microscope. Then there would be millions of particles visible only with a powerful microscope. All in these two groups are clay particles and it would require 10,000 of them of average size, set side by side, to measure an inch. They can be examined by mixing some soil with water in a fruit jar. Let it stand for 20 minutes for the coarse particles to settle. Pour off the muddy liquid into a second jar or thinner walled glass vessel and set this aside for 2 or 3 days. It is then possible to see the successive layers of finer and finer sediment from the bottom upward. This fine material will be found to have a soft, greasy feeling on the fingers. It is very sticky and when it dries it shrinks and gets very hard. It will also crack during drying and form lumps. These are all properties of pure clay and result from its extreme fineness. There is no distinctive chemical quality of clay.

Silt. Next above the clay particles is another size of particles, also too small to see with the naked eye, called silt. It would take 1,000 of these particles of average size to measure an inch. If the muddy water in the fruit jar mentioned above were first poured off in about 2 minutes and the liquid let stand for 20 minutes before pouring off the liquid carrying the clay, the fine material in the second jar would be largely silt. This has a soft, velvety feeling to the touch; it is neither gritty nor greasy. When it dries it sticks together but it is not particularly sticky nor does it become very hard. The lump may be easily crushed in the fingers. It is more like flour than like anything else.

Sand. The next coarser particles are those that can be seen with the naked eye. They are the different grades of sand, from fine to coarse, beginning next to the silt with the very finest. Four grades of sand are recognized. Of these, it would take about 350, 150, 70, and 35 particles respectively to measure an inch. All these grades are gritty but they do not stick together or get hard when dry. Clean beach sand and dune sand are good examples. Sand particles above these 4 sizes are designated as gravel, boulders, or simply as stone according to size. The term gravel usually implies particles that have been smoothed and rounded by being carried and rolled by water.

Natural soil is a mixture of particles. It is evident that different soils will show a different proportion of these different sized particles when laid out in a line according to size. Some soils, ordinarily known as clay, would contain only the smaller sizes. But even the finest clay will contain nearly as much silt and very fine sand as pure clay. On the other hand those fine, friable, easily worked bottom lands along the larger streams, which are usually made up mostly of silt, will contain from 10 to 20 per cent of clay as well as 20 to 30 per cent of fine sand. Further, sand and gravel soils will contain from 10 to 40 per cent of silt and clay particles.

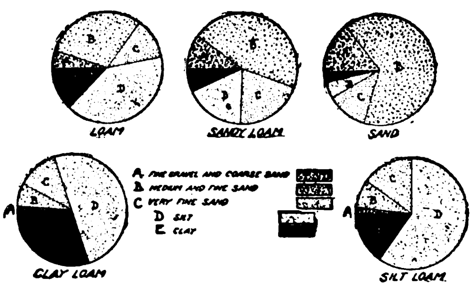


FIG. 9. Proportions of the different sized soil particles in representative types of farm soils

It is, therefore, evident that soils as we see them in the field are mixtures of particles of different sizes. No natural soil is made up wholly of one size. The properties of soils are due to the proportion of particles of the different sizes they contain. However, fine particles have more effect on a soil than an equal weight of coarse particles.

Field classes of soil according to fineness. There may be every gradation in these proportions. In this way a very large number of soils according to fineness may be obtained. A clay soil is one that has so much of the clay sized particles that it has most of the properties of pure clay. In the same way a silt soil has enough silt particles to give it most of the properties of silt; fine sand soil is made up largely of fine sand; and gravel soil is made up largely of gravel particles. When all the different grades of particles are mixed together without any one dominating the mixture we have a blending of properties. Such a mixture is fairly fine and loose; it generally works up in good condition; but if worked when very wet it is sticky and becomes hard when dry. Such a blending of soil particles gives a *loam soil*.

More often, in spite of an evident mixture of many grades of material, some one grade has dominance. That is, the soil may be a loam but may contain enough clay so that it is better described as a clay loam. Or, if medium sand is dominant, it is a sandy loam; if silt, it is a silt loam, and if gravel, it is a gravelly loam. On the other hand, a soil is sometimes better described by reversing the order of the descriptive words. A clay containing enough sand to require the recognition of that material is a sandy clay—a common material in the Coastal Plain region of the Southern states. A sand or sandy loam with considerable gravel is a gravelly sandy loam. Thus is the textural name of a soil made up.

Pore space in soils. All soils are porous. This is generally understood. They must be porous so that they will hold water and air, give up their plant-food and permit the roots of plants to thread their way through their mass. The size and volume of its pores or the spaces between its particles make up one of the most important properties of a soil; and these depend largely on the size of the soil particles. Large particles form large pores or interspaces; small particles form small spaces. In very fine clay soil the pores may be so small that roots cannot press through them. Such a soil would be called impervious.

Very small spaces absorb and hold water more readily than very large ones; they also hold more water in proportion to their total volume. Remembering that the soil must store water for the use of plants, it will be seen that this effect of the soil pores in regulating that storage is very important.

Small pores act very much like the spaces in a loosely woven lamp wick. The water forms a very thin layer around each soil particle and the curve of the water surface between every 2 particles draws the water forward toward the drier soil. If the pores are very large—as in gravel and clean, coarse sand—the films of water do not fill the pores and the pulling action by which the water is held in or moved into the dry soil is not very strong. Such a soil is "droughty." It will not hold enough water to carry large crops through the periods of dry weather.

It is evident that a medium-sized pore space as usually found in the finer and loamy soils, is best for crop production. Silt loams and clay loams are excellent for most purposes. But because of the character of their pore spaces, extremely fine and extremely coarse soils are likely to be poor.

The amount of pore space in average soils is surprisingly large—from one third to one half of the volume. That is, in a cubic foot of soil as taken from the field the spaces between the soil particles occupied by water and air would total from one third to one half of a cubic foot.

Surprising as it may seem, fine soils usually have more pore space than coarse soils. Clay loam may have more than 50 per cent of pore space while clean, sand soils seldom have much over 33 per cent. The larger the volume of pore space and, therefore, the larger the amount of water a soil is able to hold (up to two thirds of its total volume) the better is the moisture relation of that soil for crop production.

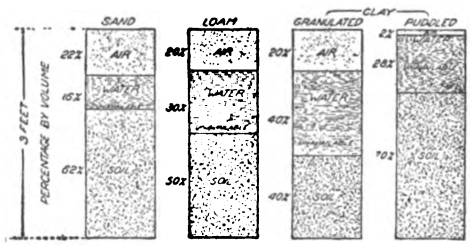


FIG. 10. Proportions of soil, water, and air in sand, loam, and loose and puddled clays

Tilth and structure of soil. The size of the pore spaces is determined by the arrangement of the soil particles as well as by their size. In a soil having considerable coarse material and consequently pores too large to be fully effective, these pores may be reduced in size by being partly filled with smaller particles. A mixture of silt or clay and fine sand particles gives pores of a more suitable size than a mass of either size particle alone. This is one of the reasons for the usual superiority of loamy soils. This favorable arrangement of the soil particles constitutes good tilth, physical condition or *structure*. That is, a soil of suitable texture or fineness may have either a suitable or unsuitable structure. By packing its finer particles into the spaces between its larger ones, a soil is rendered more and more dense. This process may be continued with a soil of mixed fineness until a large proportion of the soil spaces is filled, and there results a very dense mass that affords little or no storage for water and no access to the roots of plants. Such a soil takes on a stone-like hardness. It is difficult to plow and forms large lumps or clods when broken up. This is a poor structure and such a soil is said to be "puddled." Such a condition can only be produced by working the soil when very wet and letting it dry in that condition. Clay is puddled in making brick and tile to secure the desired density and hardness, and in a sandy or gravelly soil a certain amount of puddling may be desirable. But any soil of average or more than average fineness may easily be damaged by such treatment.

Granular structure is desired. In very fine-textured soils where the pores are too small and the soil is inclined to be too dense, an arrangement known as the granular structure is desired. Several small particles when cemented together act like a larger particle. When fine soils have the right amount of moisture and are stirred, they fall apart in a fine crumbly condition, the crumbs or small granules constituting good tilth. Such soil must be thoroughly moist but not wet enough so that water may be squeezed out with the hand or brought to the surface when the soil is jarred in a vessel or steadily patted for a time.

Hardpan. Any layer of soil that either naturally or artificially has been made too compact and dense for fair crop growth may be called a hardpan, although the term means different things in different regions. In arid regions, it usually means a soil where the pores have become filled with some chemical substance carried in by the soil moisture, such as lime carbonate.

Weight of soil. The weight of a soil is not of much importance to the practical farmer. Ordinary field stones of different kinds weigh from 160 to 180 pounds per cubic foot. Upland soil is made up of essentially the same material but it is porous and, therefore, weighs less. Thus a cubic foot of clay soil in ordinary tilth weighs from 70 to 85 pounds; of loam and silt loam from 80 to 90 pounds; and of sand and gravel soil from 90 to 110 pounds.

An acre of soil one foot deep weighs from 3,000,000 to 4,000,000 pounds or from 1,500 to 2,000 tons with 1,800 as a fair average for ordinary upland soil. Muck and peat soils weigh much less—from 400 to 800 tons (these figures being for the dry material).

Internal surface in soil. The amount of surface exposed by the particles of a soil is surprisingly large. This affects the capacity of the soil to retain water and also the freedom with which the plant-food in the particles is given up. It also determines the extent to which fertilizers are retained. If the surface of all the particles in a cubic foot of ordinary clay loam soil were unfolded and laid down in one continuous plain they would have an area of from 3 to 4 acres. For each acre of soil a foot deep there are approximately 150,000 acres of surface. In loams and sandy loams there are from 1½ to 2 acres of surface per cubic foot or from 50,000 to 75,000 acres per acre foot of land. Coarse, clean sand will have only 15,000 to 25,000 acres of surface per acre foot of soil. Not all this surface is

effective since part—probably half—is used up by being in touch with other particles.

Color of soil. The color of soil is a prominent characteristic. Most of it is due to one of two materials: humus and compounds of iron. The humus, formed by the decay of organic matter, produces the various shades of brown and black; different combinations of iron produce the red, yellow, blue, and some of the gray colors. A red color indicates good drainage; yellows, blacks, and uneven browns indicate poor drainage. The natural color of soil particles is gray and most of the color seen in the field is a surface stain that can be washed out.

The color of a soil is a useful sign as to its condition and gives the experienced eye some clue to its origin and chemical composition. Dark-colored soils are usually regarded as fertile when drained because of the large amount of organic matter present.

All these properties are in the main incidental to those things that immediately concern the farmer's practices. But as soon as he begins any detailed study of soils, even though for purely practical purposes, a knowledge of them comes into use.

The Survey and Classification of Soils

Every person who has any acquaintance with land, that is, the soils of the field, has arranged in his mind the differences he recognizes in the soils of different areas. He has in mind the difference between the silt of the river bottom, the clay of the lake flat, and the gravel or sand or stony loam of the upland. He also observes color differences, separating the dark-colored, swampy hollows from the lighter-colored, higher land. He may know areas of dark red soil, of yellow, light gray or nearly white soils. He knows that some of these areas are rich in lime and sweet, and grow clover readily while others are acid or sour, do not grow clover and need lime.

Such an outline of soil conditions, covering an area of soil with which that particular person is acquainted, is a purely personal possession. It probably goes most into detail with regard to his own farm, representing merely the organization of his knowledge of soil conditions in the field. But it constitutes a soil survey.

Such knowledge or survey is used in one's observations of crops as one passes by on the road; it is used when he sets out to buy a farm or take part in any operation involving the soil or its products.

Any one person's knowledge of the soil, especially if he has not made a special study of the subject, is quite limited, fragmentary, and not standardized into observations and descriptive terms that other persons understand. Nor is it readily available to other persons. Consequently, there is the need for a more systematic observation and record of soil conditions on a larger scale. As a result there has been started in several quarters what is formally known as the soil survey.

The soil survey. This consists of an examination in the field of the soil of different parts of a farm, a county, or a state. A fairly small area, usually a county, is ordinarily chosen. The soil expert equipped with his soil auger (usually 3 feet long) and perhaps with chemical materials and apparatus for special examinations, proceeds by foot, by horse and buggy, or by motor, to go over the county systematically examining its soils.

He studies the soil carefully to a depth of at least 3 feet and makes observations to still greater depths so that he becomes very familiar with it fully as deep as it can affect crop growth. He travels all or most of the roads, observing and examining conditions by the way. He leaves his conveyance and covers the fields on foot, always making borings with his auger, observing road cuts, post holes, ditch banks, plowed fields, the action of the

soil on the different tools, the type and growth of crops, the character of wild plants, the drainage and the movement of water in the soil—everything in fact that his experience tells him will give a cue to the soil characters and differences. He studies the properties of each soil; he interviews farmers along the way, and questions them about the character and working qualities of their soils and their response to different crops and different methods of treatment.

As a result, the survey expert collects a large amount of information about the character of the soils in that area. It is the same kind of knowledge that every observing farmer has, but it is immensely more complete. Often such a man is able to see more in a half hour's inspection of a farm than the owner has discovered in years of practical farming. This is because of his fund of experience and general knowledge of the soils of that region.

The next problem is to record all this information in such form that others may use it. This requires a classification of the different soils recognized, a representation of their location and a description of their character and properties.

The classification of soils. Since the agricultural value of the land for crop production is the primary concern of the soil survey, those properties are used in the survey that have the most direct relation to its value. First, there is texture. Is the soil sand, gravel, silt, clay, or of some related class? Second, what is its color, light or dark? Has it much or little organic matter? Third, is it rich in lime carbonate, or is it sour? Fourth, is its drainage good or poor? Fifth, is the soil arranged in layers or is it a promiscuous mixture of materials? Is it in good tilth, or is it hard and puddled? Sixth, does it contain any unusual amounts of soluble substances that would injure or benefit crop growth? This is especially important in arid and semi-arid regions. Does it have an alkali crust or an accumulation of alkali salts at any depth near the surface? And if so, are these salts black or white? As the result of a classification based on such characters the surveyor may recognize in a county many different kinds of soil.

The soil type. Each kind of soil is called a type, just as each kind of fruit is called a variety. A soil type comprises all those land areas in which are found the same characters or qualities. Of course, it is impossible to recognize in a field classification every last difference found in soils. As many as 60 different types have been recognized in one county, but usually there are from 15 to 30.

The soil series. Upon examining a number of different types, the surveyor finds that several of them have properties in common. While of different fineness they may all be rich in lime, or poorly drained or low in organic matter. Thus a group of types having important characteristics in common is recognized and called a *series*.

Naming the soil type. Soils, like persons and places, must have names by which they can be identified. A type of soil is named by first giving its textural designation, for example clay, silt, loam, or sand. Then some geographic name is selected for the series. Usually this is the name of some place near where the series is first recognized. For example, the Marshall series which covers much of the dark prairie region of the Middle West takes its name from Marshall County, Minnesota. The Orangeburg series takes its name from Orangeburg County, South Carolina, where large areas of the dark red soils of the Southern Coastal Plain were first recognized and studied; the Fresno series includes soils first recognized near Fresno, California; the Ontario series is named after Ontario County, New York, where fruit production is a leading industry on soils of a certain character.

This double name of a soil type then becomes its individual designation to be used wherever that type is found. To the informed person, the name always conveys the idea of certain definite characteristics. By means of the soil survey it is, therefore, possible to refer to a particular kind of soil by name with as much precision as it is possible to refer to a White Oak tree or a Trumper Creeper vine.

The soil map. The distribution of the soils in the county or area under survey is represented on maps. The location and extent of each type of soil are indicated by a special color. Such a map should at least show the roads, streams, and towns and it is much more satisfactory if it shows also the houses and contour of the hills and valleys. The scale of most of these maps is an inch to the mile. On the border of the map the colors are labeled so that the types may be identified.

The soil survey report. Each soil map is accompanied by a report describing the general situation of the area, the character of its surface, its agricultural development, its history and its climate. The character and distribution of the soils are discussed at some length and each type is described in considerable detail; there is included a statement as to its characteristics, crop relations, and agricultural development, and suggestions as

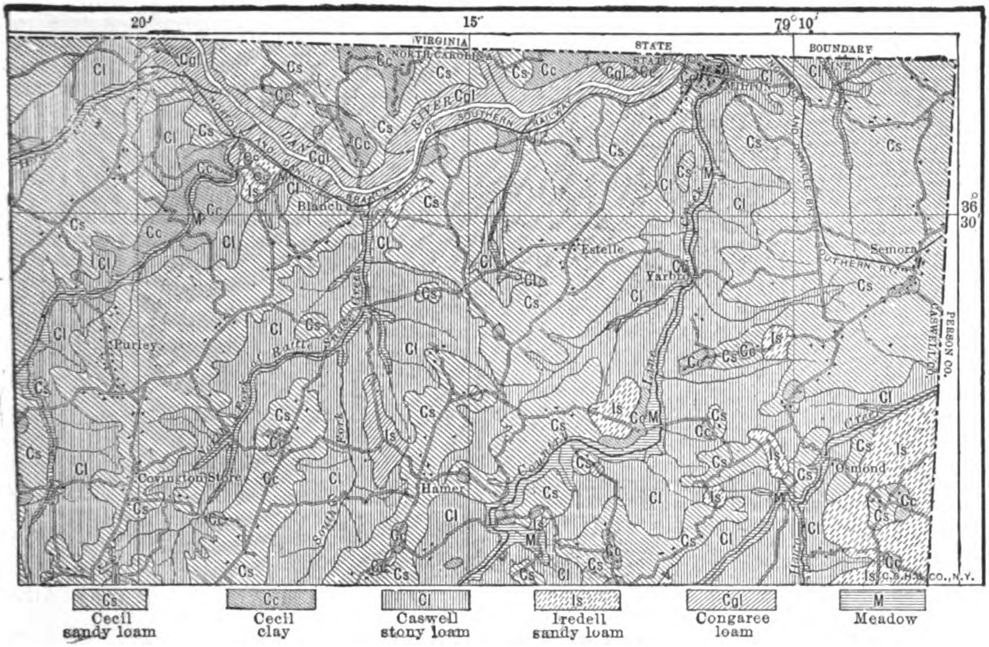


FIG. 11. Part of a soil map as prepared by the U. S. Bureau of Soils. As published, these maps show the soil types in colors; some of them give also the topography or surface irregularities

to the more prominent needs for its improvement.

The map and report are printed and distributed through some governmental agency either free or at a small charge (about 15 cents) to cover the actual cost.

Who have made the soil surveys. Most of the soil survey work has been done by, or in coöperation with, the United States Department of Agriculture. A key may be secured from that office which will tell any interested person what areas in the United States are covered by the soil survey and where the reports may be secured.

Several states, including Illinois and Iowa, have undertaken independent soil surveys of their respective state, and their reports are published by their state experiment stations. The province of Ontario, Canada, has begun a survey of its soils in about the same form as has been adopted in the United States. Several European countries have also made soil surveys.

Up to January, 1918, about 500,000 square miles had been covered by detailed soil surveys; an even larger area has been covered by reconnoissance or small scale detailed surveys.

In the United States over 2,500 different kinds of soil have been recognized and these are distributed in over 600 soil series.

Uses of a soil survey. The soil survey amounts to an inventory of the soil resources of a region. For the county, the state, or the general government it shows the kinds, extent, and general value of its farm lands. It makes agricultural institutions, experiment stations, departments of agriculture, and schools of agriculture acquainted with soil conditions and enables them better to recognize, study, and correct the soil conditions that need improvement. It brings such institutions in closer touch with the individual farmer and his conditions.

For the farmer and land owner the soil survey supplies an unprejudiced statement of his general land conditions, shows how his land compares with other regions, gives a basis for the choice of crops and tillage practice, and a reliable, general guide in buying or selling land. Of course, a soil survey cannot show *all* the detailed soil differences, but it is by far the best available guide to practical conditions. The information it presents is more and more being used by all agencies dealing with the land. After all, it is the natural character of the soil more than any other single condition that determines the distribution and development of a region's agricultural industries.

Examples of the crop adaptation of soil series. A number of soil series and types have become widely known for certain qualities by many farmers and others

acquainted with the soil. Much of the upland prairie land of the Middle West, the ideal corn and small-grain soil, is embraced in the "Marshall series" of which the loam and clay loam are the most extensive types.

FIG. 12. Suggesting the wise use of different soil formations: the cropping of the rich bottom lands and the pasturing and foresting of the poorer uplands which, under cultivation, are more likely to wash.

A large part of the land on the New England hills of a yellowish-brown, color and quite stony and irregular, is embraced in the Gloucester series. The finer textured types of good depth and extent make very fair farming land and are famous for the production of blueberries. The coarse, sandy types are pretty poor farm lands. As a whole the soil is acid and needs lime. The Ontario soils in central and western New York, particularly the loam and fine sandy loam types, are the best tree fruit land. Apples grow particularly well on them where the climate is at all favorable. This soil has a fair supply of lime and humus and makes an excellent grain soil, and is also much used for beans and cabbage.

In the Middle Atlantic States the Sassafras and Collington series, mostly brown, sandy soils rather low in lime but rich in the elements of plant-food, are the leading soils for vegetable and fruit production. Farther south in the Coastal Plain belt are the yellow upland soils—the Norfolk series—and the dark red soils —the Orangeburg series—that are largely used for cotton production. Both are acid. The yellow soil grows good light tobacco in favorable climate belts, and is a good soil for peanuts as it does not stain the shells. The Orangeburg soil is better for grain and forage crops. In southwest Georgia the sandy loam types constitute the best soil for the production of peaches and pecans. It is better drained than the yellow soil, but both are very low in lime and organic matter and need heavy feeding.

The famous black soils that lie in a belt across the middle of the Gulf States from Alabama to Texas are known as the Houston series. They are rich in lime and organic matter and on the whole are very fertile. The better class of residual limestone soil of middle Kentucky, Tennessee, southeastern Pennsylvania, and the Great Valley of Virginia, are known as the Hagerstown series. The dark red soils of the eastern slope—the Piedmont—of the Appalachian Mountain region, most used in that region for general farming, are mostly the Cecil series. A red, sandy clay is most common here. In the higher mountain districts of western Virginia is a similar soil mixed with much more organic matter so that in the field it has a dark brown to black color. This is the Porters series. Especially where it is found at an elevation of 1,200 to 2,000 feet it forms the best fruit soil of that section, and has become especially famous for the production of the Albemarle Pippin apple.

CHAPTER 2

How and Why Soils are Poor

By PROFESSOR ELMER O. FIPPIN, *who, in Chapter 1, explains just what soils are, what they are made of, and how they were or are being made. As every farmer knows, few soils are as fertile, as productive as they might be or as we would like to have them. This chapter explains why this is the case and in what way soils may be poor. This knowledge, added to an understanding of what materials go to make up soil formations, naturally leads us to the discussion, in Chapter 3, of how poor soils can be made better.*—EDITOR.

WHY soils are unproductive. The more common causes of unproductiveness in soil may be listed under three general groups: (1) Those of a *physical* nature, which have to do with the tilth or physical conditions of the soil, its density or porosity, its supply of organic matter, poor regulation of the water supply—too much or too little water—and injuries resulting from washing or blowing. (2) Those of a *chemical* nature, which have to do with a lack of one or more of the necessary plant foods, with acidity or sourness, alkali crusts or an excess of soluble material, and with difficulties due to the accumulation of poisonous materials. (3) Those of a *biological* nature, which have to do with (a) the presence or absence of organisms needed to carry on useful processes, such as the fixation and transformation of nitrogen; (b) changes in the composition of the organic matter; (c) the production of compounds injurious to plants; and (d) the development of diseased conditions brought about by organisms that live part of their life in the soil. Usually these difficulties do not appear singly but in combinations. For instance, too much water causes poor ventilation, which checks the activity of organisms that hasten the decay of organic matter and the freeing of plant-food. It also makes the soil colder and interferes with tillage operations.

Physical Causes of Poor Soil

HARDPAN. Poor tilth is one of the most immediate causes of soil unproductiveness. The soil may be so fine and dense or so closely packed—"puddled"—that it does not easily take up moisture or permit the entrance of roots. Or, if the moisture is taken up, it may fill the soil pores and crowd out the air. Such a soil is called a *hardpan*, which is merely a layer that is too impervious. It prevents the free, downward movement of moisture and of plant roots; it prevents the free upward movement of water in times of dry weather. The entire soil section may be of this hard character, or it may be confined to a thin layer at any depth. Unless it occurs within 3 feet of the surface, it is usually not very injurious. Its effect even at that depth, however, will depend on the depth of rooting of the crop and the general conformation of the land. A thin layer of soil so compact as to act as a hardpan is frequently found in water-formed soils. In a generally sandy formation there may be a thin layer of fine clay that interferes with the proper functioning of the soil. In areas of muck soil subject to occasional overflow, there may be deposited thin layers of fine clay which are later covered by further accumulations of muck that are very completely cut off from the muck below the clay layer. In arid regions, where the soil contains considerable soluble materials, a hardpan layer is frequently formed by the accumulation of one or more of these chemical substances in the soil pores, often in a rather thin layer, Carbonate of lime is the most common cause of such hardpan. Wherever this hardpan layer is thin and near the surface the remedy is clearly deep plowing, which breaks it and mixes it with the coarser soil and thereby improves the physical condition of the entire mass.

Again, a hardpan layer is frequently devel-

oped in fine soils, such as clays, by continuously plowing at exactly the same depth. The weight and pressure of the plow and the tramping of the team packs the bottom of the furrow. A variation in the depth of plowing from year to year will correct this.

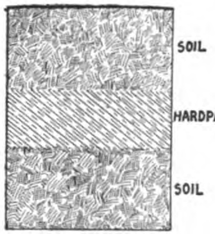


Fig. 13. A simple hardpan formation that can be improved by blasting.

Lumpy condition. A compact soil inclines to break up in a coarse, lumpy condition if worked when too dry. The lumps act like so many boulders and form a soil that is too open. Water from a sudden, heavy rain quickly runs through such a soil; roots do not readily penetrate it; nor can they secure the moisture and food they need. To improve such a condition, the lumps must be broken up by plowing when the soil is in just the right condition as to moisture. It must then be worked down with the harrow, clod crusher, and drag until it is properly fined and compacted. When a soil is in the moderately moist condition, that is, best for plowing, there is very little danger of making it too compact by working it.

This right moisture condition for tillage is known to every experienced farmer. It is that in which a handful of soil squeezed in the fingers sticks together moderately well, holds the form in which it is molded, but shows no free moisture on the surface. When turned up by plow or cultivator, a soil in this state rolls over as a granular or crumbly mass without showing any shiny or pasty surfaces. The soil that is worked when too wet is the one that becomes too compact and hard.

Coarse texture. Coarse, open, sandy and gravelly soils are even more difficult to improve and maintain than more compact, fine soils. The pebbles, stone, or sand particles are too hard to be broken up and there is often not enough fine material to fill the large spaces. Soils of this character need to be worked when rather wet and to have added finer material in the form of fine earth and humus to partially fill up their spaces. They are usually described as droughty or dry, and crops on them quickly wilt and wither in periods of dry weather. The more they can be packed the better. Often rather shallow plowing is desirable; but if manure or other organic material is being added, it usually is best to plow rather deep to incorporate the material.

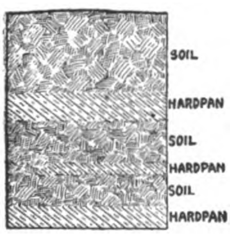


Fig. 14. Hardpan sometimes occurs in several layers, making its correction more difficult..

Lack of humus. Humus is the agricultural name for organic matter in the soil; a lack of it usually goes along with poor soil tilth and is indicated by a light color. Pure organic matter as usually found in soil is best illustrated by muck, a fine, friable material which never becomes very hard nor very loose and open. However, as applied to soils, the term organic matter includes all manner of both plant and animal remains whether added to the soil naturally or artificially.

What humus is. This organic matter undergoes in the soil rather rapid change. As it decays it loses its coarse, fibrous structure and becomes dark brown or black in color, and also more soluble. A large part of it may be dissolved in a solution of ammonia or soda lye, especially if it is first washed with a little water that is mildly acid. The solution is a brown or black liquid, the same as the familiar coffee-colored material that leaches from a well-rotted manure pile, or the brown water frequently seen in the streams that drain mucky or swampy areas, in the Southern states.

If some of this brown liquid is boiled down to a thick paste the result is much like tar. If dried out it shrinks and cracks, becomes shiny, black and hard and breaks up into moderately hard lumps or cubes resembling coal. This is humus, or that part of the organic matter that has partially broken up as a result of decay and is capable of uniting closely with the soil. For this latter reason it has a greater effect on the productiveness of the soil than the woody or chaffy parts of the organic matter.

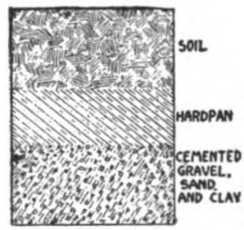


Fig. 15. If hardpan is underlain by a non-porous layer its improvement is still more difficult.

Organic matter is rapidly lost. Organic matter decays and consequently, unless the supply is replenished, it disappears from the soil sooner or later. The better ventilated and more nearly perfect the soil is as regards moisture, the more rapid is this decay. Consequently organic matter disappears more rapidly from a sand than from a clay soil, in which the moisture and poorer ventilated condition hinders decay and permits organic matter to accumulate.

The average well-drained upland soil of sandy texture contains about 1 per cent of organic matter; clay soil contains 3 per cent. Of course, where a soil of either texture is poorly drained, there is a larger accumulation. Swampy sand soils of a dark or black color may thus contain from 4 to 10 per cent of organic matter and clay soils, under similar conditions, from 6 to 20 per cent. Its pres-

1-ENLIVENS THE SOIL
2-MAKES HOME FOR BACTERIA
3-LETS AIR AND WATER INTO THE SOIL
4-RETAINS THE MOISTURE
5-KEEPS SOIL LOOSE AND WARM
6-MAKES THE SOIL PRODUCTIVE
7-PREVENTS WASHING AND BAKING

FIG. 16. Some things that humus does (Courtesy International Harvester Co.)

ence or absence is indicated by the color of the soil; as a rule, the more organic matter it contains, the darker it is.

How organic matter is lost. Organic matter is exhausted from the soil because it is continually undergoing a slow process of burning. If put in a furnace, it burns up—that is, the materials that make it up are changed into gases and driven up the chimney and only the ash or mineral material remains. Practically the same thing is happening in the soil and in the manure heap. The action is not a pure chemical one as in the case of fire, but, just the same, the process of decay through the agency of mold bacteria and other forms of life breaks down the organic matter, reduces it to simpler and simpler gases until all of the plant that was originally gaseous has come again to the same gaseous condition.

The reader should keep in mind that in the soil he is dealing with there are two different types of material: (1) the mineral or rock material which is stable, permanent and not easily lost; and (2) the organic material made up very largely of carbon, nitrogen and the elements of water, all of which may be pulled apart from their combinations in the plant substance and returned to the atmosphere.

EROSION means "a gnawing or wearing away." To the farmer it means the cutting away of the soil by the flow of water following periods of heavy rain. Injury from erosion occurs in two ways: (1) the soil, especially the surface soil which is usually its best part, is carried away by the force of the water, exposing the subsoil which is much less adapted to produce crops: (2) the surface may be cut into such an irregular mass of gullies, hollows, and ridges that systematic tillage is hindered or made impossible.

Erosion occurs in two ways: (1) As a result of either a very heavy downpour of rain or of a very compact surface soil, the water is confined on the surface and, if the land is sloping, rushes down in rivulets of ever-increasing volume. Water flowing at such a speed carries pebbles, clods and stones which are moved both in the body of the stream and by being rolled along the surface of the soil. These become the tools of the current adding to its cutting power by their own bombardment on the sides and bottoms of the channel. The effect is to carry away the soil and perhaps to cut deep gullies and holes into the land. This is perhaps the most common type of erosion and may be seen anywhere after every heavy rain. It is more widespread but less deep-seated and injurious than the second type; still, it is responsible for much injury.

(2) Whenever any fine earth material having little cohesion (tendency to stick together) is saturated with water, it takes on the properties of a fluid and flows like a thick liquid. A fine, sandy loam underlaid by a heavy clay or other impervious layer may thus become filled with water because of heavy or prolonged rainfall. The entire mass, if it lies on a slope, may then be set in motion and flow down the hillside in thick muddy rivulets. This also is a common type of erosion against which every region of long summers, heavy rains and light winter freezes must be guarded. It makes necessary the contour farming so common in the Southern states. It cannot be sharply separated from the first type of erosion by surface flow and when the two processes combine the contour farming must be reënforced by side hill ridges or terraces.

Serious erosion frequently occurs as a result of the soil-water finding its way several feet into the ground where there is a fine sand or silt layer containing very little clay to bind it together. Such material when saturated with water becomes "quicksand" which then oozes out at every possible point, especially along the face of a slope. There may be heavy clay above but as the quicksand oozes out below and the foundation is removed the bank above comes down and the erosion eats its way deeper into the hillside. This type of erosion has been responsible for the destruction of large areas of farm land

FIG. 17. The result of one year's uncontrolled erosion on a fine-textured soil. This may take 5 years to rectify.

FIG. 18. Erosion covered this road several inches deep with fine soil brought down from the farm lands on the hills. Cropped fields are sometimes injured in the same way.

in the Coastal Plain regions of the world where the soil formation is a series of layers of gravel, sand, and clay materials.

Closely related to this type of erosion is the occurrence of landslides. In some parts of the world the earth material at a few feet below the surface is quite compact while just above is a more porous layer. When the upper soil is saturated with water from heavy rains, perhaps reënforced by springs, the entire surface layer of soil, lubricated by the water, may slide down the slope. An immense mass of earth covering acres, with all its covering of vegetation, including trees, may thus be thrown into the valley in one jumbled mass.

Still another type of erosion occurs along the course of streams where they come in contact with soft, sandy banks. The force of the current and the lap of the waves cut into the base of these banks; the higher part then caves in; and the process begins over again. The material cut away may be deposited on the opposite side of the channel farther down, or as low islands. This type is confined chiefly to stream bottoms and is the process by which a stream changes its course by working slowly over the ribbon of flat land along its course and forming it into successive terraces that may be observed along nearly every stream. A short way above its mouth, the Missouri River has, within the memory of farmers now living, changed its course by thousands of feet and destroyed entire farms of fertile soil.

Damage caused by erosion. The total damage done to farm land by erosion even in recent times is worth hundreds of millions of dollars. It is generally more severe in regions where the soil does not freeze. Here there are likely to be heavy downpours of rain; also the soil is more compact than where freezing occurs.

FIG. 19. Eroded gullies and lack of drainage take a toll not only in the form of crops but often in the form of valuable livestock.

Stone in and on the soil tends to protect it from erosion. A covering of vegetation, whether it be trees or grass or merely weeds, breaks the force of the rain: the roots hold the soil in place; and, if there is a covering of leaf mold, it absorbs much water and reduces the injury from erosion. The removal of forests, especially in steep and mountainous regions, has been widely held up as an example of unwise and destructive land management.

LACK OF WATER. Three fifths of the earth's surface has a shortage of rainfall for fair and regular crop production: one fourth has an arid climate with an annual rainfall of less than 10 inches. This shortage of rainfall is responsible for vast desert and semidesert areas in many parts of the world.

It requires, under average conditions of

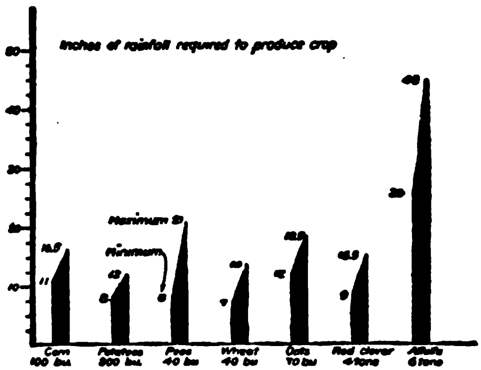


FIG. 20. Rainfall used in producing common farm crops. Each black strip shows the minimum (on left) and the maximum (on right) amount needed.

climate, from 15 to 20 inches of water to produce an average crop of dry matter. Of this, half or less is actually used by the crop. The remainder is lost directly from the soil as a feature of the production of the crop. Of course, these proportions vary. The point is that rainfall or the lack of it is one of the most widespread handicaps to larger crop production. The efficiency of a given number of inches of rainfall depends on how it is distributed, the temperature of the atmosphere and especially the character of the soil. The water held in the soil bridges over the periods between rainfalls and makes possible the continuous growth of plants.

The storage of water in the soil depends first and most on the fineness of the soil. (See Chapter 1). The coarser the soil particles and the larger the spaces between them, the smaller the amount of water the soil can store. It is primarily for this reason

that a boulder pile is practically barren. Until the soil reaches the fineness of fine sand it cannot hold moisture to bridge the average period between rains. Even soils of the best texture—sandy loams, loams, and silt loams—may be unable to bridge periods of lack of rainfall, commonly called droughts.

On the other hand, the soil may be so fine that for all practical purposes, its water supply is unavailable to crops. There are a few heavy clay soils in humid regions where on all higher elevations the native vegetation has many of the characteristics of desert vegetation.

The quantities of water actually used by plants in producing large yields are shown in Fig. 20. The variations for the same crop are largely due to differences in climate. In addition, nearly an equivalent amount is required to provide for the ordinary losses direct from the soil during the year. The sum, or twice the amounts of water given, would be the amount necessary to produce the stated yield of crops, which are typical of all that are grown.

Water storage capacity of soils. The number of inches of available water that could be stored in a section of soil 3 feet deep is given in the table below This is the depth the farmer should expect to use if his soil were in first class physical condition. The unavailable water is that part held so tightly by the soil that it cannot be used by the crop. It is the last thin layer of water on the particles and, of course, is largest in the finer soils.

It will be seen that a 3-foot section of ordinary soil is able to store as much water as is used by crops in making an average yield—about one third the yields given in Fig. 20. This may be stored from the winter rainfall; but to it may also be added that of the summer months. Moreover, the farmer is not necessarily confined to a soil depth of 3 feet for the storage of moisture. It has been demonstrated in Utah, for example, that crops are able to use the moisture stored in the soil to a depth of 8 feet or more.

EXCESS OF WATER. Nature is not accommodating to the farmer in the distribution of rainfall. In all regions of the larger rainfall there is likely to be a surplus of moisture at some season of the year. In the eastern third of the United States about one half of the annual rainfall finds its way into the drainage systems and is carried off by the rivers. In the Western states where the distribution is much more irregular, a smaller proportion is drained away, but there are still many areas over-supplied with water. In arid regions having a rainfall of 10 inches or less, there is no drainage.

AVAILABLE WATER RETAINED BY DIFFERENT SOILS

TEXTURE OF SOIL	WEIGHT PER CU. FT.	WATER RETAINED IN 3 FEET		
		Total	Unavailable	Available
Beach sand	110 lbs.	2.5 in.	0.6 in.	1.9 in.
Light sandy loam	100	5.8	2.3	3.5
Fine sandy loam	90	7.8	3.6	4.2
Loam	85	9.8	5.8	4.0
Silt loam	80	11.5	6.0	5.5
Clay loam	75	15.0	8.6	6.4
Heavy clay	70	18.0	12.0	6.0
Muck	15	17.0	8.7	8.3

FIG. 21. A field clearly in need of drainage. Thousands of acres in such shape are wasted every year

What is a surplus of soil water? Remembering that the moisture used by most farm crops is that which is permanently held in thin films on the soil particles, we can see that moisture in the soil in excess of that amount is a surplus and is objectionable for purposes of crop production because it occupies the larger soil pores that should be filled with air. The immediate result is a poorly ventilated soil to which most cultured crops are unsuited since they must have oxygen for their roots just as animals require it. It is true that some air is dissolved in water, but in the soil this amount is quickly exhausted and is very slowly replenished because the soil water does not have the free circulation that occurs in bodies of water.

A soil should be regarded as having a surplus of water to the extent of wetness (1) whenever water stands or shows freely on the surface; (2) when an excavation to a depth of 2 or 3 feet will show standing water for more than 3 days at a time; (3) when the soil is subject to serious heaving and "honeycombing" due to freezing. The experienced observer will note many other common signs of a wet soil such as a miry or soft condition, "springy places" due to seepage, weedy spots in hay and grain fields, and an uneven or mottled color of the subsoil, especially when accompanied by a very dark-colored top soil.

Bad effects of excess water. 1. A wet soil is easily puddled and takes on a hard, lumpy condition unsuited to crop growth. Tools and animals mire in its insecure foundation and all tillage operations are inefficient.

2. Surplus water excludes the air necessary for deep root development. In wet soil the roots of crops are confined to the surface layer and are unable to make effective use of the plant food in the deeper layers.

3. The shallow rooting of crops, together with the unfavorable tilth, increases the difficulty with which plants secure moisture in

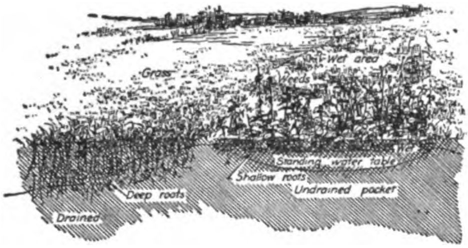


Fig. 22. Where drainage is poor, root growth is also poor. This means a weedy crop correspondingly small and of little value.

periods of dry weather. Therefore, crops on soil that is temporarily wet suffer more in dry periods than crops on either permanently wet or normally moist soil. Excessive wetness for more than 2 or 3 days is sufficient to injure if not to kill the roots of many crops.

4. Surplus water in a soil makes it cold in two ways: (a) The amount of heat required to warm a pound of water is 5 times as much as is required to warm a pound of soil to the same temperature; (b) the evaporation of water uses up much heat. It requires as much heat to evaporate 1 pound of water at 80 degrees F. as is required to change the temperature of a cubic foot of dry soil (weighing 80 pounds) by 60 degrees. Since the source of the heat of the soil is almost entirely the sun, and since this is a fixed supply for each unit area of the earth's surface in the same latitude and position, it follows that the wetter the soil is the longer it takes to become warm enough for germination and plant growth in the spring. In this way, and because wet soil cannot be tilled early, the effective growing season is shortened.

5. The defective ventilation, shallow rooting of crops, poor physical condition and low temperature that prevail on wet soil all render the plant food—and especially that in the subsoil—less available to crops than in well-drained, merely moist soils; and this condition interferes with the activities of many forms of bacteria and fungi in the soil with resulting injury to crop growth.

6. Surplus water in the soil, especially when it reaches the point of saturation, is the primary cause of heaving. When wet soil freezes, the water in it expands about 10 per cent of its volume; the resulting expansion lifts the surface layer of soil or squeezes the moisture out through the larger pores in ice columns commonly known as "honeycomb." This pulls and breaks crop roots and is a common cause of winterkilling, especially of tap-rooted crops such as clover.

7. Excessive wetness of the soil, especially in the crop-growing season, delays tillage and planting operations, makes them less effective, and generally increases the cost of crop production by reducing the efficiency of the farm equipment. In the course of a series of years this in itself is a source of large loss to the farmer.

Types of wet land. There are many kinds of wet soil of which the following are typical:

1. Soils of a rather compact nature from which the water does not drain freely but in which the surface layers quickly become saturated during periods of heavy rain. Clay soil and soil having a hardpan near the surface are in this group. This is one of the most common types of wetness in cultivated fields and constitutes a temporary condition that is even more disastrous to the farmer than a permanent one, for crops are likely to be planted and lost, whereas on permanently wet soil tilled crops are not likely to be planted and the chances of loss are reduced. Immense areas of land in farms, north and south, east and west, are wet in this way—because of the impeded movement of the surplus rainfall. It does not matter that such land is situated on a slope. When the upper layer of soil is saturated, the condition continues for many days because of the slow flow of the surplus water through the subsoil. Often such a soil is distinguished by a gray or mottled layer below the surface and just above the hard subsoil or hardpan where excessive seepage occurs.

2. Springy or seepy land where a porous soil comes in contact with a more impervious layer. Deep layers of sand and gravelly soil underlaid by clay or other impervious material are wet near the foot of the slope of coarse soil. The foot of nearly every hill and bank is wet from the seepage of the soil above. Rock may come near the surface and throw out the water in large springs. Limestone outcrops on top of shale and sandstone usually show large springs, which therefore, are merely the underground flow of the surplus water from the soil.

Low, flat, or basin-shaped areas, especially if they have a rather impervious subsoil, receive the drainage and seepage from the land higher up and are thus made wet. The largest development of this condition is the lake. Next, come temporary lakes and next beyond that, a merely swampy condition in which water stands to a shallow depth for all or most of the season and where water-loving plants grow. The heavy growth of vegetation in such places, together with its partial preservation as it accumulates on the surface, has resulted in many areas of peat and muck. Such material can accumulate only under very wet conditions. The less developed stages are the black, marshy soils throughout many parts of the world, especially in the glaciated part of the northern hemisphere where many such wet pockets have been formed. When drained and developed, these marsh and swamp lands constitute much of the best farm land in the country for forage and vegetable crops.

4. Creek and river bottoms subject to

overflow are frequently wet. The overflow is one source of the surplus water. It is likely to accumulate in the old bayou channels and low pockets back from the main channel and is usually supplemented by seepage directly from the upland.

5. Tidal marshes make up rather large areas and form low, flat sand and mud flats frequently covered by the coarse, salt, swamp grass. In Holland and in some sections of the coastal region of the United States, such land has been reclaimed by keeping out the tide with dikes and by building systems of drains.

Extent of wet land. It has been estimated that there are more than 80,000,000 acres of swamp land in the United States awaiting development. This is as a rule potentially fertile soil and constitutes one of the great reserve land areas of the country. It does not follow, however, that because it is potentially good land its reclamation and development are demanded by the needs of the country for crops. In fact, it would be a national disaster to reclaim this land too rapidly. The cost is considerable and should be borne by the land that is improved. In normal times at this stage of the nation's development, the increased crop that could be produced would so over-supply the markets that the whole of the agricultural area would suffer as it has suffered most acutely from the too rapid development of the free lands of the United States under the various homestead acts. This refers to great schemes for federal and state reclamation of such land similar

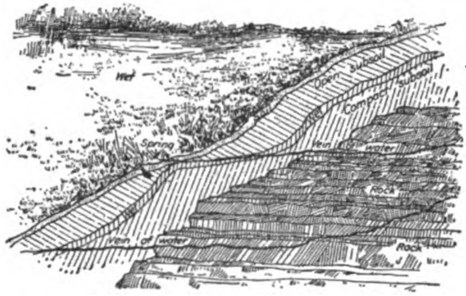


Fig. 23. Section of a hillside showing how the layers of porous soil and hardpan cause the formation of springs and wet places.

to the reclamation plans that have been carried on along irrigation lines; for the problem with drainage is even bigger and, on its economic side, more serious. However, the gradual development of such land to meet the economic needs of the country is to be encouraged.

The better drainage of the wet lands already in farms and under tillage is an even more important economic problem for the farmer and for the country than the present development of swamp land. This is land being farmed at low efficiency because of its wetness; no assurance of better crops and regular returns can be given, whatever the treatment, until that development is made. It is a very conservative estimate that one-half of the cultivated land in the country needs additional drainage.

Chemical Causes of Poor Soil

It is a common and true statement that the soil is a complicated chemical laboratory. The many soil particles, both mineral and organic, are made up of a number of elements or fundamental constituents combined in different ways. Some of these are used by plants as food and, therefore, the soil must be considered from the point of view of its capacity to supply all of these essential elements in the amounts and at the time they are needed. This opens up the whole question of the insufficient nutrition of plants by the soil which is well known to be a common cause of unproductiveness.

A further relation between the soil and its chemical properties is the effect the presence or absence of these chemical substances may have on the soil as a congenial place for plant growth. They may be present in such amounts, in such combinations, or to such a degree of solubility as to interfere with growth. They may even destroy plant tissues already produced.

The four main groups of these chemical conditions in the soil that interfere with plant growth are: (1) deficiency in available plant nutrients; (2) acidity or an unfavorable balance between the acid and the basic materials; (3) alkali or the presence of an excess of soluble material; and (4) toxic (poisonous) materials present in the soil solution.

Deficiency of plant nutrients. Ten chemical elements are required by plants. These are *carbon, oxygen, hydrogen, nitrogen, potassium, phosphorus, sulphur, calcium, magnesium, and iron.* (See Volume 4, Chapter 17, for a discussion of these and other chemical terms.)

Carbon forms about half of the dry substance of plants. Its final source, as far as plants are concerned is the carbon dioxide of the atmosphere of which it forms from 3 to 5 parts in each 10,000. This small amount is filtered out by the leaves of plants and broken up to furnish the necessary carbon. More directly, carbon is taken up from the soil as carbon dioxide and also as more highly organized forms in the organic matter. It does not seem likely that a deficiency of carbon ever limits plant growth.

Oxygen makes up from 35 to 40 per cent of dry plants, forms nearly 89 per cent of water, and nearly 20 per cent of the atmosphere, and in addition enters into many combinations in the soil. The general supply is unlimited but its deficiency in the soil may seriously interfere with root development and the general useful activity of the soil. Of course, it is abundantly supplied to the tops, but the roots may suffer from a lack of it which is the same thing as lack of ventilation. For purposes of growth most of the oxygen used by plants is supplied by water.

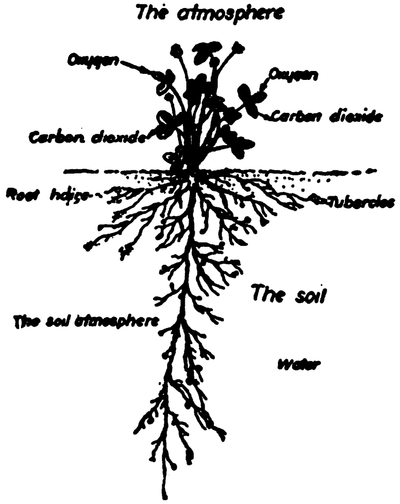


Fig. 24. The plant lives not only on the soil but also on the atmosphere, both above and below the surface of the ground.

Hydrogen makes up from 5 to 7 per cent of dry plants and forms about 11 per cent of water, from which they secure most of their supply. Experience has not shown that the lack of hydrogen for food purposes limits plant growth.

Nitrogen makes up from $1\frac{1}{2}$ to 5 per cent of the dry substance of plants and forms $\frac{4}{5}$ of the atmosphere by volume. However, while the atmospheric nitrogen is the ultimate reserve supply, it is in such a form (that of free nitrogen gas) that none of the higher plants can use it directly. Plants use nitrogen only in some combined form, for example, united with oxygen to form nitric acid (HNO_3) or with hydrogen to form ammonia (NH_3), or in higher combinations in the form of organic matter. All of these combinations may be derived from the organic matter in the soil which, so far as is known, is the only direct source from which higher plants secure the required nitrogen. It is evident that the available supply of combined nitrogen, which is so closely identified with the organic matter in the soil, may easily be deficient; or that, if the organic matter does not undergo decay with sufficient rapidity, crops may suffer from a lack of nitrogen.

Here it should be explained that higher plants—farm crops—are continually using the nitrogen from the atmosphere through the aid of low forms of plants—bacteria and fungi—that under suitable conditions are able to take the free nitrogen gas and unite it with oxygen or hydrogen to form combinations that they can use. When these small plants have finished with the nitric acid and ammonia, it is passed on for the use of the higher plants. The best known example of an organism that carries on this nitrogen fixation process is *Bacterium radicicola*, common in the nodules on the roots of all leguminous plants. The organism is benefitted by its host plant and in turn confers on it a supply of available nitrogen. This is an excellent example of practical coöperation and the control of such coöperation is largely the basis of successful crop production. If the organisms that produce the nodules and fix the nitrogen are not present or if the conditions are not favorable for their growth the soil may be unproductive until these things are corrected.

Within recent years it has been learned that there are other organisms in the soil that live independent of higher plants and are able to fix the nitrogen of the atmosphere in combinations that higher plants can use. The best known group is one of bacteria known as *Azotobacter*. These seem to be found in all well-ventilated soils. The investigation and regulation of these processes offer a large field for further work.

Finally, 5 to 10 pounds per acre of ammonia and nitric acid are annually brought down from the atmosphere by rain and snow and added to the nitrogen supply in the soil.

Lack of available nitrogen is a very immediate and serious cause of unproductive soils; and since the combined nitrogen in the soil is so closely identified with the supply and condition of the organic matter there, it may be said that the supply of organic matter is a leading factor in soil fertility. The soil organic matter contains from 2 to more than 15 per cent of combined nitrogen and serves as a storehouse. Any system of farming that permits the supply of organic matter to run too low, or to become too unavailable through stoppage of decay, not only brings on direct insufficient feeding of the plant, but also induces a long chain of unfavorable processes many of which are physical.

GREATEST POSSIBLE NUMBER OF CROPS THAT COULD BE PRODUCED BY THE TOTAL QUANTITY OF EACH PLANT NUTRIENT IN AN ACRE FOOT OF SOIL (See Table, p. 27)

CROP	YIELD PER ACRE	NITROGEN		POTASSIUM		PHOSPHORUS		SULPHUR		CALCIUM		MAGNESIUM	
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Corn	50 bu. grain and stover	135	13	2,857	42	266	37	571	57	2,836	63	1,875	43
Wheat	25 bu. grain and straw	220	22	5,888	88	400	56	571	57	6,500	140	4,285	35
Oats	45 bu. grain and straw	270	27	3,940	44	320	45	666	66	4,000	87	3,000	70
Red clover hay	2 tons	125	12	1,333	25	320	45	333	33	711	15	882	20
Alfalfa hay	3 tons	61	6	1,111	16	228	32	222	22	500	10	625	14
Potatoes	200 bu., 2 tons tops	227	22	1,660	25	355	50	533	53	8,000	175	3,750	87
Apples	300 bu., 2 tons leaves	185	18	1,818	27	533	45	1,333	133	627	13	1,000	23

It is important to observe that the four usually gaseous elements already discussed (carbon, oxygen, hydrogen, and nitrogen) form from about 90 to more than 95 per cent of the dry substance of plants. The ultimate supply of these is unlimited and, except in the case of nitrogen, its control as well as its study is essentially outside the province of soil management (See Chapter on Chemistry, Vol. IV).

Mineral plant nutrients. The six mineral elements that form the remaining 5 to 10 per cent of the dry plant substance are secured by the plant in solution entirely from the rock particles of the soil. All together they form from 3 to as much as 15 per cent of the dry substance of plants. With some other mineral matter not of use to the plant but present, accidentally, they form the ashes that remain when a plant is burned.

A soil may be unproductive because of a shortage in the total supply of one or more of these elements. It may also be unproductive because they cannot be made soluble and carried to the plant roots in sufficient amounts. This involves the entire problem of the moisture supply and the physical condition of the soil.

Potassium is the mineral element used in largest amounts. It enters particularly into the roots, stems, and leaves, and forms nearly 1 per cent of the dry substance. In the soil, it is the most abundant of the mineral plant-food elements. All the younger soils, the glacial and the recent residual soils contain from 1½ to 3 per cent. On the other hand, some of the very old siliceous (sandy) soils, including much of the sandy Coastal Plain of the American continent, contain much less than 1 per cent.

Another group of soils that is notoriously deficient in potassium is made up of mucks and peats. Shortage in both the absolute (entire) and the available supplies of potassium may limit plant growth. This result is more likely to occur in the mineral soils of the Southern states and in muck soils everywhere than on the soils formed by glacial action; for wherever the ice sheet moved the rocks have been ground up mechanically without much loss of their constituents.

Phosphorus usually stands next to potassium in the proportion of the ash it forms. The mineral composition of plants varies widely, depending on the composition of the soil, and it seeems probable that the amounts of any of the constituents found in the ash of plants do not represent the minimum required to grow that crop. For this reason, exact statements of the proportion formed by any mineral element may be accidental rather than necessary. At any rate, it may be said that phosphorus is used by plants in much smaller amounts than potassium. It forms from two tenths to four tenths of 1 per cent (.2 to .4) of the dry substance of plants. It is necessary to every cell but more abundant in the grain than in any other part of the plant; a good supply produces large grains. On the other hand, phosphorus is perhaps the element of plant food most often deficient in the soil. Since there is nothing else to do but to add it, the use of phosphorus is one of the most widespread needs in soil fertilization.

The usual amount of phosphorus in soils is from three hundredths to one tenth of 1 per cent (.03 to .1), but some soils run considerably above or below these amounts. Some of the very siliceous Coastal Plain soils with only 500 pounds of phosphorus in the surface foot of soil per acre illustrate an extreme deficiency.

Sulphur stands close to phosphorus in the amount used by crops and in the supply in the soil. Grain and grass crops appear to use about two thirds as much sulphur as phosphorus. On the other hand, legumes and the mustard family use much more sulphur than phosphorus.

Over against these facts must be considered the further fact that soils are about as deficient in total sulphur as of total phosphorus. The per cent present is nearly the same, varying, of course, from soil to soil. Both elements have a tendency to accumulate in the surface layer of soil. In spite of the apparent marked deficiency of sulphur in the soil, the element does not appear to be anything like as important a controlling factor in crop yields as phosphorus, yet it is a factor to be kept clearly in mind in dealing with fertility problems.

COMPOSITION OF REPRESENTATIVE AMERICAN CROPS

CROP	YIELD PER ACRE	POUNDS PER ACRE OF					
		Nitrogen	Potasium	Sulphur	Phosphorus	Calcium	Magnesium
Corn grain	50 bushels	50.0	9.5	5.0	8.5	1.0	3.0
Corn stover	1.5 ton	24.0	26.0	2.0	3.0	10.0	5.0
Wheat grain	25 bushels	35.5	6.5	4.0	6.0	1.0	2.0
Wheat straw	1 ton	10.0	10.5	3.0	2.0	4.0	1.5
Oats grain	45 bushels	25.0	7.0	3.0	6.5	1.5	2.0
Oats straw	1¼ ton	12.0	27.0	3.0	3.0	6.0	3.0
Clover hay	2 tons	80.0	60.0	12.0	10.0	45.0	17.0
Alfalfa hay	3 tons	140.0	90.0	18.0	14.0	67.0	24.0
Potatoes	200 bushels	44.0	60.0	7.5	9.0	3.5	4.0
Apples, fruit	300 bushels	24.0	28.5	1.0	2.5	1.0	2.0
Apple leaves	2 tons	30.0	27.0	2.0	3.5	50.0	13.0

Lime. Calcium and magnesium are termed the lime elements and serve much the same purpose. Grain, grass, and trees use relatively little lime as food, but leguminous plants of all kinds make a large use of it and its lack may limit their growth. On the other hand, the supply of lime elements in the soil compared to the amount needed for plants is much larger than that of phosphorus and sulphur. Further, if there is a deficiency for food purposes, it is likely to express itself first in acidity of the soil which will be the primary cause of a resulting low yield. The relation of lime to acidity will be considered further along.

Iron is the last of the mineral elements. It is used in least amounts by plants and is present in most soils in largest amounts of any of the mineral elements. Lack of iron does not seem to be a limiting factor in crop growth to any important extent.

The relative requirements of crops for the important mineral plant nutrients are summarized in the three accompanying tables. The first (p. 25) shows the amount of the elements required to produce stated yields of a few common crops. The second (above) gives the composition (and suggests its range) of some representative American crops. The third (p. 27) lists the relative supplies of the elements in the surface foot of the soil and calls attention to those that are most likely to limit plant growth. The supply of the elements, except nitrogen, is quite as large in the lower layers of soil as in the surface foot, a fact that suggests the advisability of permitting crops to root as deeply as possible.

Why plant food is unavailable in the soil. The data thus far presented deal with the source and supply of the plant nutrients. Attention must be given not only to the total supply but to the conditions that make them available—or unavailable. The following factors are likely to bring about the latter condition:

1. A dense, impenetrable condition due to fine texture, puddling, or both, so that the plant roots cannot come into contact with the nutrients.
2. Lack of moisture to dissolve the plant food. This occurs in both arid and humid regions when the soil moisture supply becomes low.
3. Excess of moisture as a result of which the roots are unable to deeply penetrate the soil.
4. Low temperature, usually due to excess of moisture in the soil. Plant food is dissolved from most minerals more rapidly at a high than at a low temperature. Dark-colored soils and those sloping to the south are warmest.
5. Poor ventilation interferes with many of the processes that make plant food available. This is closely associated with wetness and a bad physical condition. Thorough drainage and tillage are the most efficient means of improving the ventilation of the soil.
6. Lack of organic matter makes the soil constituents less available. In the process of decay many soluble compounds, including finally carbon dioxide, are produced and these increase the power of the soil water to dissolve plant food. It is also important through its effect on the moisture and physical condition of the soil.
7. Lack of chemical substances, lime in particular, reduces the availability of the soil material.
8. Lack of active organisms in the soil, including both bacteria and fungi, results in slower changes in the organic matter and consequently reduced availability. Muck soil is one of the best illustrations of this point. The conditions under which it has been accumulated have interfered with the activity of decay organisms. After such soil is drained and opened up by tillage, it gradually develops a flora or group of decay organisms. This process is usually hastened by the applica-

tion of stable manure which is abundantly supplied with decay organisms. Thereby, the nitrogen in particular, of which muck soil contains from 2 to 3 per cent, is made available.

There is a close relation between all the physical conditions of the soil and the availability of the nutrients it contains. Since most soils contain a large total supply of these nutrients within the root zone, it is of first importance that the physical conditions be correctly adjusted.

Soil Acidity

The chemical balance in the soil. The chemical constituents of the soil may be divided into two groups. One includes all those elements that have properties called variously alkaline, basic or sweet. The most abundant basic elements in the soil are potassium, sodium, calcium, magnesium, iron, aluminum, and ammonia (which is the result of the union of 1 part of nitrogen with 3 parts of hydrogen). The other group includes all those elements and chemical radicals that have acid or sour properties, of which the most abundant are carbon dioxide, chlorine, sulphuric acid, nitric acid, phosphoric acid, silicic acid and a long list of organic acids that result from the decay of organic matter. In the soil these two groups are united in various combinations and when so united one neutralizes the properties of the other. Some of the elements and radicals are very active chemically and unite readily with the opposite sort. Others for example, silica or silicic acid, are less active because less soluble. While an acid, the last mentioned is so slightly soluble that its acid properties in themselves are not seriously injurious. But if there are not enough basic elements to satisfy all the other acid materials, and at least some of the silicic acid, there is a condition of acidity in the soil.

Another way to state this is: that both acid and basic materials are present in every soil and unless acid materials are pretty largely satisfied, the soil will have acid or sour properties.

There are soils that have a large surplus of active acids. There are also soils that have a large surplus of active bases and are, therefore, alkaline. But the more common condition is a soil nearly balanced as to these two groups of materials, that is, a nearly neutral soil. A moderate degree of acidity is more common than a moderate degree of alkalinity, while soils of extreme acidity or of extreme alkalinity are much less common than the intermediate condition.

Adjustment of plants to the soil balance. Most plants are accustomed to grow in soil where the balance between the active acid and basic constituents is somewhere near equal. But some plants are accustomed to grow on a very acid soil and do not thrive on a very basic soil; and others are accus-

COMPOSITION OF REPRESENTATIVE AMERICAN SOILS

	POUNDS PER ACRE FOOT OF					
	Nitrogen	Potassium	Phosphorus	Sulphur	Calcium	Magnesium
Glacial soils						
Marshall silt loam	10,000	66,000	3,200	2,500	25,000	10,000
Memphis silt loam	3,500	50,000	1,400	500	8,500	5,000
Volusia silt loam	5,000	50,000	2,000	1,500	5,000	6,500
Gloucester stony loam	5,000	60,000	1,800	1,600	32,000	12,000
Residual soils						
Hagerstown loam	5,000	65,000	3,000	4,000	22,000	15,000
Cecil clay	3,000	16,000	2,000	1,000	10,000	4,000
Cecil sandy loam	2,500	25,000	1,200	700	10,000	3,600
Durham sandy loam	4,000	100,000	1,800	800	22,000	3,200
Great Plains soils						
Oswego silt loam	7,500	65,000	1,500	1,500	25,000	6,000
Colorado sand	3,800	63,000	1,600	1,200	25,000	12,000
Coastal Plain soils						
Norfolk sand	1,000	1,500	450	400	700	350
Norfolk fine sandy loam	2,000	2,000	500	500	1,200	400
Orangeburg sandy loam	2,500	3,000	900	1,200	1,500	450
Susquehanna clay	3,000	1,000	800	800	2,500	1,500

tomed to grow on a very basic soil and will not grow on a very acid one. Thus each plant has a range in the strength of the acid or alkaline condition it will stand. Near the middle of this range, variation one way or the other does not have much effect on its growth. Whenever a soil is too acid for the best growth of a plant, the condition must be corrected by the addition of some basic material.

It may be quite as important to maintain an acid condition of soil for certain plants as it is to maintain an alkaline condition for others. Some common plants that grow best in an acid soil are watermelon, chestnut, broom sedge, and arbutus. But the plants that grow best on a neutral or alkaline soil are much more common. They make up a much larger number of the plants that are economically important than do those plants that will tolerate much active acid. Nearly all the leguminous crops, such as clover, alfalfa, peas, and beans and the root crops, such as beets, radishes, and onions grow best on an alkaline soil. The grain and grass crops and potatoes, and perhaps cotton and most of the fruits, grow best on a neutral or only slightly acid soil. It is, therefore, more important to agricultural practice to avoid a strongly acid condition than it is to avoid a strongly basic condition.

The basic materials are lost from the soil more rapidly and in larger amounts through leaching than are the acid constituents. Consequently, the older a soil is and the longer it has been cropped, the more is acidity likely to be developed in it.

Since old soils are more common than young ones, sour soils, in this sense, are very common. They are found in every section of the humid regions and may be found in arid sections. It is safe to say that 75 per cent of the farm land in all humid regions is sufficiently acid to need correction for a good rotation of crops. The ancient residual soils, even those derived from limestone, and the old soils formed on the ocean floor, are usually very deficient in basic materials, the proportion of acid soils in these regions running much above 75 per cent. Nearly all the southeastern and a large part of the northeastern quarter of the United States is seriously acid. Glacial soils formed from siliceous sandstones and shales are very deficient in basic material, but other glacial soils are fairly well supplied with lime and if limestone has entered into the composition they are likely to be heavily charged with it, especially in the subsoil. The correction of the acidity is one of the fundamental problems of soil improvement and where needed must receive attention even ahead of fertilizers.

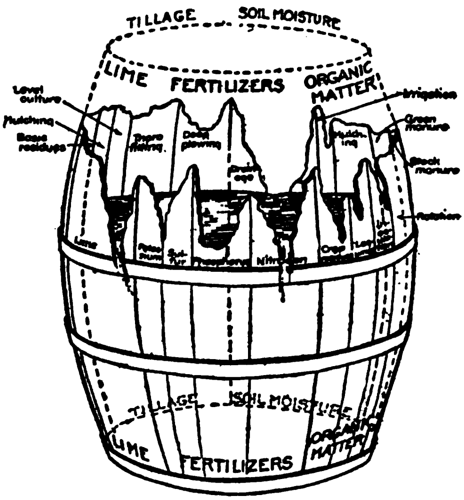


FIG. 25. A broken barrel holds water only to the level of the lowest of its broken staves. The productivity of a soil is only as great as the least abundant factor permits it to be. We must, therefore, keep our soils in good condition generally and not well supplied with certain elements but deficient in others.

ALKALI. Alkali in relation to the soil means any excess of soluble material therein sufficient in amount to interfere with plant growth. The salts that constitute this soluble material are not necessarily alkaline in the sense that quicklime is alkaline; some of them may be acid in nature.

Alkali salts injure plants (1) by making it hard for them to take up soil moisture; (2) by being taken up in such amounts as to kill the plant cells; (3) some constituents of alkali may corrode the woody tissues of plants; (4) some of the constituents of alkali may undergo changes that lead to their deposition in the soil in rather insoluble form giving rise to a hardpan which interferes with the movement of water and the penetration of plant roots.

In arid regions. Alkali is most common in arid and semi-arid regions, especially after irrigation has been practised for a few years. Under such climatic conditions there is not enough water to cause deep seepage. Thus the products of solution of the soil accumulate from year to year and from century to century until they make up a rather large percentage of the soil material as compared with the soluble material in regions of humid climate. But even arid soils seldom have a serious accumulation of alkali in their native state; that is, this soluble material is ordinarily distributed through a deep section of soil and is not enough to prevent plant growth. When water is added by irrigation it works its way deeply into the soil before all of it is held in capillary form. It may penetrate to great depths, the surplus gradually piling up in the subsoil in the form of a saturated zone. If water continues to be added in excessive amounts or continues to seep in from some irrigation ditch passing through porous soil at a higher level, this water-table grad-

ually rises toward the surface of the land in the lower places.

In either case, evaporation occurring at the surface pulls the water in that direction. The evaporation of the water leaves the soluble salt behind usually as a crust on the surface. When this reaches a certain concentration, plants cease to thrive or live there. When the soil is of uneven texture or structure, evaporation of some of the capillary moisture may occur at some depth so that a very dense alkali layer is formed in the subsoil.

In humid regions. In regions of high rainfall, small spots of soil may occasionally accumulate enough soluble material to warrant description as alkali. Such spots may be quite as barren of vegetation and have just as well developed crusts as alkali soils in arid regions. They usually occur where a spring strongly impregnated with soluble material reaches the surface. Salt licks are an example of this sort of alkali spot.

Composition of alkali salts. It might be expected that the salts that make up soil alkali would be as varied in composition as the soil itself. This is not true, however, because many of the constituents of the soil are too insoluble in all their combinations to enter largely into the accumulations of soluble material. Alkali crusts are made up chiefly of the more soluble bases—sodium, calcium, magnesium, and potassium—united with the more soluble acid radicals that include chlorine, sulphuric acid, carbon dioxide and, to a limited extent, nitric acid. Any of the bases may be united with any of the acids. Where calcium or magnesium unites with carbonic acid, the two form the rather insoluble lime carbonate which gives rise to a hardpan, due to the cementing of the soil particles.

Common salt (sodium chloride) is the most common constituent of alkali crusts, but chlorides of the other bases are also common. Next in abundance are the sulphates, mostly magnesium and sodium sulphate. Nitrates and carbonates are much more rare. The chloride and sulphate salts form white incrustations and are known to the farmer as *white alkali*. The more resistant plants such as beets, sorghum, grapes, and the date palm will withstand about 1 per cent of such salts in the surface soil. Of course, if it is concentrated in a crust or hardpan, such an amount may be fatal to even these plants. Other crops are able to withstand a less amount down to about one half of 1 per cent. Soluble carbonates are most injurious because some of their salts, especially sodium carbonate, dissolve the tissues of plants producing a blackish color, wherefore they are called *black alkali*. This is tolerated by plants to a much less extent than the white sort, about one tenth of 1 per cent being the limit. Here, again, limit of tolerance depends very much upon its distribution in the soil and the amount of water present. The amount of alkali of either kind that will not be seriously injurious in a soil that is thoroughly wet, will become so as the soil dries out.

Soil alkali is a most treacherous material and, to the inexperienced observer, is almost uncanny in its effects and movements through the soil. The rise of alkali is marked first by a very large crop growth, followed by the gradual dying of the plants or trees as the alkali, and perhaps the water-table containing the salts, come into the root zone. However, the presence and movement of alkali in the soil follows well-known chemical and physical laws and can be largely controlled. This control is one of the problems the irrigation farmer in arid and semi-arid regions must constantly keep in mind.

TOXIC MATERIALS. Brief mention should be made of a subject very new to soil management, but open to further investigation, because it is one of the factors that sometimes lead to unproductiveness in the soil. In this connection the fact that the soil is teeming with microscopic organisms; that it produces a variety of plants; and that it receives the residue of many others, must be constantly kept in mind.

It is well known that some chemical substances are poisonous to living organisms both animal and plant. Data at hand indicate that some of these poisonous substances may develop in the soil and injure growing crops. Careful study of many organic compounds found in the soil has clearly shown that some of these may be poisonous or toxic to plants. It appears that the same poisonous material is not found in all soils nor the same material in any particular soil at all times. The chemical substances in the soil, especially those derived from plant and animal material, are undergoing constant change. If the chemical and physical conditions are not just right, a poisonous material may develop; and it may or may not remain for only a season.

Usually the toxic materials in the soil occur where the soil is poorly drained, and consequently poorly ventilated; also where it is deficient in lime and subjected to continuous heavy cropping. The continuous growth of the same crop may result in an accumulation of residual materials that will injure it, although they may not be injurious to a different type of plant. Herein lies one of the reasons for crop rotation.

Another group of toxic materials is distinctly mineral in nature. Some of the compounds of aluminum and silica have been found to be a cause of infertility by the Indiana and Massachusetts Experiment Stations. In Hawaii, in soils devoted to pineapples, it was found that too much manganese may sometimes be present, and a similar condition seems to have been found in the States. In the case of the alumina and silicate compounds, their presence seemed to be associated with physical conditions, such as

poor drainage and lack of lime that the experienced farmer recognizes as undesirable.

Biological Causes

There should be at least a brief mention of the possibility of organisms being the occasion of unproductiveness. More and more it is being recognized how dependent the farmer is on the presence and activity in his soil of microscopic living bodies that he can not see and whose presence he may little suspect. It is now known that every soil is teeming with these organisms—bacteria and thread-like plants of many kinds. If these do not carry on their functions the soil may be unproductive; if the necessary kinds are not present in the right proportions trouble may arise.

The best example of a type of soil organisms whose absence may lead to unproductiveness is that which causes nodules on the roots of clover, beans, peas, alfalfa, and similar plants, and which, if the supply of soil nitrogen is deficient, are able to use the free nitrogen of the air, causing it to unite in compounds that the host plant can use. Their absence may lead to nitrogen starvation.

If a soil is sterilized (that is, if its bacteria are killed) either artificially by heat or chemicals, or naturally as a result of poor drainage and the lack of lime, the organic matter will cease to decay and, therefore, to give up its constituents to the growing crop. Muck soil is often rather unproductive because of such a condition.

So far as present knowledge goes the lack or failure to act of those organisms that have to do with the fixation and changing of nitrogen is most likely to be the cause of unproductive soils. The practice of soil inoculation is based on this fact. It seems likely that further investigations will show more clearly the relationship of the soil organisms to its productive qualities and thereby make definite one more factor in the problem of fertility.

Another type of soil organism that is important in its relation to plant development is that which causes plant disease. Many forms live over on suitable food materials in the soil and attack their host plant when it develops, as, for example, the scab organisms of potato and beets that thrive in a sweet soil; those of the finger-and-toe disease of cabbage; blight of the potato; flax wilt; collar rot of apple trees, etc. The control of these must be a recognized part of soil or at all events, farm management. (See Chapters 27 and 29).

In view of the many possible causes of unproductiveness discussed above, it is clear how insufficient, for practical purposes, a mere chemical analysis of soil and plant is. The idea that chemical analysis will reveal the difficulty that a fertilizer can correct seems to have taken a firm hold on many minds. It is vitally important that farmers get a new point of view and appreciate the importance of *all* the factors that have been discussed in this chapter.

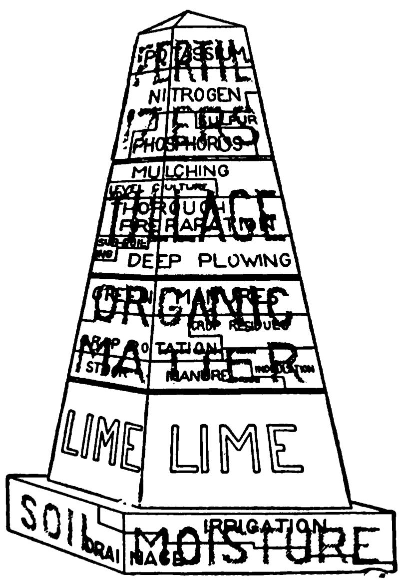


FIG. 26. A monument of soil fertility, showing the essential factors and how they are all related and dependent one upon the other for the productivity of the soil as a whole.

CHAPTER 3

How Poor Soils May Be Improved

By PROFESSOR ELMER O. FIPPIN *(See Chapter 1). When a man becomes owner of a farm from which he must make his living, he has to take things as he finds them and do his best with what is at hand. Thus he often has to grow crops on land which is not in the best shape; again he often has to experiment with a soil to find out what it is good for or what it needs. But finally he solves this latter problem and discovers which of the troubles described in Chapter 2 he must combat. The following pages tell what he must then do, and how he can best do it, in bringing about better conditions for plant growth.*—EDITOR.

THE farmer has slowly learned by experience many ways to improve the soil. At first he gathered the wild plants for his use. Then he learned that he could increase the supply of the products he desired by planting the seed of those plants in places favorable for their growth. The earliest records of agricultural practice indicate that at first the farmer did very little to improve the soil he planted. He sowed the seed and took what nature gave. Then he began to discover that by a little extra treatment of the land he could secure a larger crop or one of better quality. He observed the effects of accidental treatments, the addition of a little ashes, some manure, some bones, or the dripping of water from the water skin. With all the investigations that have been made in recent years into the why and wherefore of agricultural practice, there are very few arts that had not been long practised by farmers somewhere as a result of their experience and observation.

The benefits of irrigation and of drainage have long been known. The value of clovers and of a rotation of crops have been recognized for centuries. Animal manures and the waste material from crops have been saved and applied to the soil, and lime has been used since the beginning of the Christian era. At the bottom the practice of most of the arts of soil improvement is the same as it has been for centuries. The scientific research of recent years has simply made the reasons for the beneficial effects of some of those treatments more clear; and by so doing has made it possible to apply more accurately the treatment needed and to secure more uniform results thereby.

Irrigation

As applied to soil improvement, irrigation is the artificial application of water. Its purpose is to correct a shortage in water supply in the soil, whether due to an arid climate, to an unusually low storage capacity of the soil, or to the unusual sensitiveness of a crop to a lack of an adequate water supply.

One or more of these conditions has led to the practice of irrigation in nearly every part of the world. It is practised in humid regions where the rainfall is 60 inches or more, as well as in regions having an arid climate. It has already been pointed out that three fifths of the earth has an arid or semi-arid climate. In all this region, irrigation is the chief dependence for profitable crops.

Irrigation problems. The practice of irrigation involves two general classes of problems. One class is the application of water to the land in a manner most economical of the supply and of the cost of application, least injurious to the properties of the soil and best adapted to the special needs of different crops. The other class of problems has to do with the development and distribution to the farm of an adequate supply of water. The first class of problems is purely agricultural and must be dealt with by the farmer; the second class is essentially of an engineering nature and must be handled by the engineer.

Methods of applying water. Different methods of applying water must be used, according to the conditions. The choice of the method is determined by the nature and slope of the land, the character of the crop, and the character and amount of the water supply.

If small differences in construction of works and method of applying the water are recognized, there are dozens of methods of irrigation, but all may be brought into the following 4 groups: (1) Flooding. (2) Furrow irrigation. (3) Sub-irrigation. (4) Spray irrigation. Flooding and furrow irrigation are the methods generally practised in arid regions; the other two are employed only where a small amount of water is handled, and mostly in humid regions.

KEEP THE SOIL FERTILE

HOW

1-RAISE LIVE STOCK

2-ROTATE THE CROPS

3-GROW CLOVER. ALFALFA AND OTHER LEGUMES

4-SAVE THE BARNYARD MANURE

5-PASTURE ROLLING LANDS TO PREVENT WASHING

6-ADD HUMUS—DON'T BURN THE STALKS

7-SUPPLY NEEDED ELEMENTS

FIG. 27. (Courtesy of the International Harvester Co.)

For all methods of irrigation, except spraying, the surface of the land must be leveled or at least made smooth so that the water may be applied evenly. This is particularly important in the flooding method where the water is applied in broad sheets. If the surface is uneven, the distribution of water is also uneven. Knolls are subject to excessive evaporation which will bring alkali salts to the surface and cause the soil to become unproductive. In arid regions it is the general practice in preparing land for cropping (especially if virgin land), to level the surface very carefully with scrapers and to remove all roots and stones that might interfere with the distribution of water.

It is a fortunate thing that in arid regions there is not as large a difference between the productive qualities of the soil and the subsoil as usually exists in humid regions, and that it is, therefore, more permissible to grade off the soil to fill hollows, leaving the natural subsoil exposed at the surface in places to serve as the new soil.

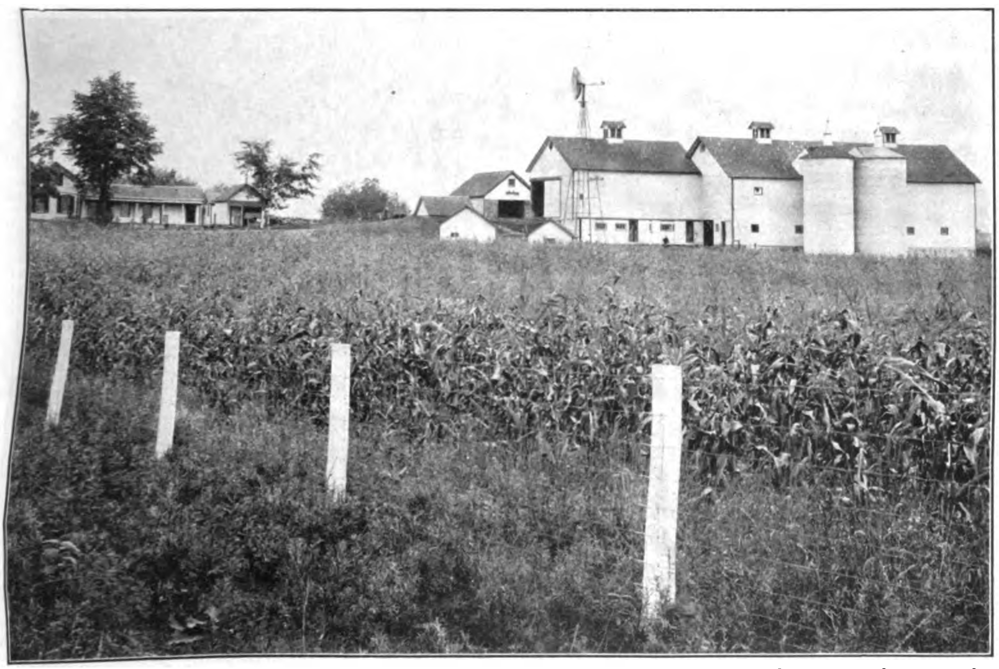
FLOODING. By the flooding system practically the entire surface is covered with water, which may be turned on in large volumes, allowed to spread over the land and stand until it is absorbed by the soil. Or, it may be turned down a smooth slope in a thin sheet or in a complete network of small rivulets and permitted to flow until the soil seems sufficiently saturated. In either case the entire surface of the soil is wet. Flooding is best adapted to land (1) where the entire area is occupied by the crop, such as grain fields and meadows; (2) where the soil is of a medium porosity and does not bake seriously on drying (heavy clay is not suited to irrigation by this method); (3) where the surface is relatively flat, or if not flat then of a smooth slope in one general direction; and (4) where the supply of water is relatively large.

Open flooding. There are many variations in the method of irrigation by the flooding system. The simplest form is to turn water on the surface of the land in the most direct way and flood the entire area to a depth of several inches. If the water is absorbed rapidly the supply may continue to flow for a considerable time. When the desired amount has been applied it is left to be absorbed by the soil. This method is applicable where the surface is flat whereon low ridges are thrown up around an area. The size of the block that may be irrigated at one time depends on the slope of the land. To irrigate large blocks where there is a large slope, entails the construction of high levees on the low side, which is expensive. Blocks of 3 to 5 acres are most commonly used, but more than 100 acres in one block have been so handled. There must be a large supply of water so that the entire area may be quickly covered to avoid over-irrigating any particular part; a flow of 5 to 7 second feet is required for the purpose, but much care must be taken to avoid erosion. One man can irrigate from 5 to 20 acres per day. Permanent levees may be constructed of a broad, low form so that machinery will readily pass over them. One difficulty is that the higher parts of the levee accumulate alkali salt in a manner described in Chapter 2.

Block flooding. Where the water is applied in small flats or basins a square rod or two in extent, the system is called basin flooding. This is frequently employed in irrigating orchards. The basins may be around the trees or between the trees, depending very much on their size. Small trees are, of course, best served by a basin around their base. But the water should not directly strike the trunk. It should be held off by a mound of soil else the trunk may be scalded if there is bright sunshine immediately following the application.

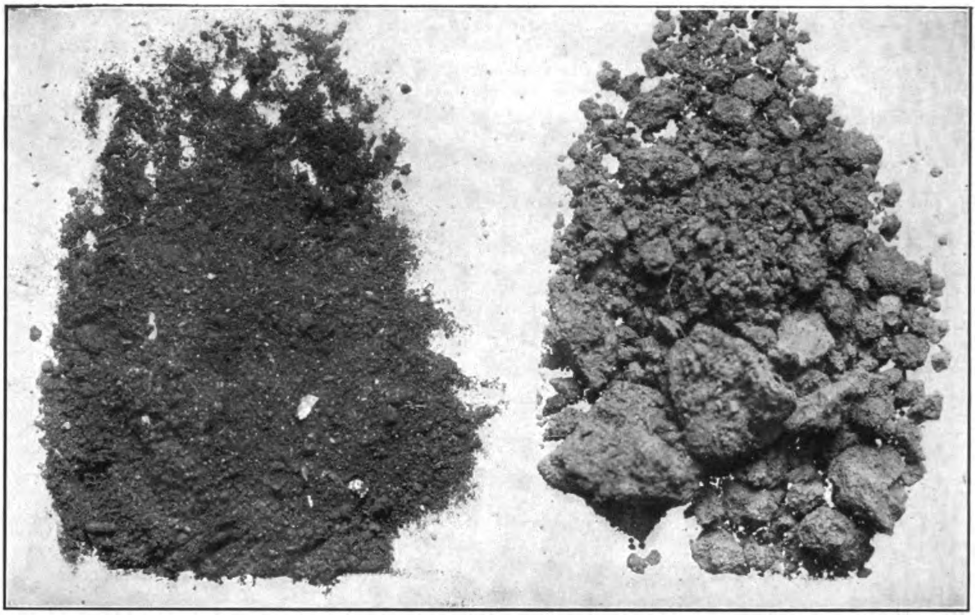
Border flooding. In some cases it is more convenient to distribute the water from trenches located on ridges at the border of the

No need to look for the weeds, the stones, the swamps, the sour spots on this farm; the abandoned, decaying home tells the story of a barren soil

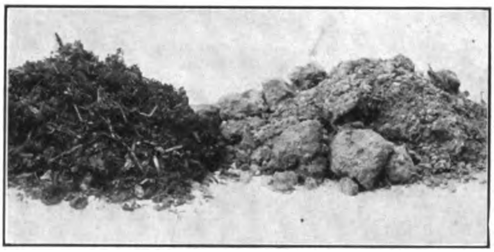


Good soil means good crops, good buildings to house them, good animals to eat them, and a good farmer enjoying the prosperity they bring

ONE WAY TO JUDGE THE WORTH OF A SOIL IS BY THE FARMSTEAD IT SUPPORTS

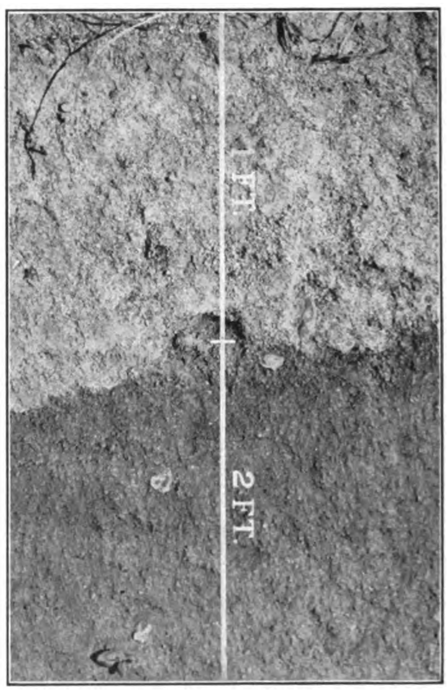


A good soil, in good condition, is friable, loose, rich in decayed organic matter and usually dark-colored. Poor soils vary; the example shown here is a stiff, lifeless, cloddy, yellow clay



Organic matter (the left-hand pile) is the life of a soil and can immeasurably improve such a type as shown at the right.

Earthworm castings, showing that Nature as well as man is constantly tilling the soil



Subsoil, brought gradually to the surface, adds to the supply of mineral plant food

Soil is Constantly Changing; it is in the Farmer's Hands Whether the Change shall be for Good or Bad

flat to be flooded. This is the border flooding system. Intensively farmed land, such as vegetable gardens, is irrigated in this way. The land should be very flat, the border trench keeping the water at such an elevation that any one of several flats may be given an application without disturbing nearby blocks.

Open-field flooding. Where the land has a considerable slope, the expense of forming border ridges to retain the water is too great. Here a moving sheet of water is best applied. The water is brought in along the high side of the field and permitted to run directly or diagonally down the slope in ditches at intervals of 30 to 60 or 80 feet, depending on the lay of the land. The steeper the slope, the easier it is to distribute the water between these ditches. The ditch attendant then begins at the upper side of the field and places an obstruction in each parallel ditch to throw the water over its edge. A common method is to use a canvas dam consisting of a stick several feet long on which is tacked a sheet of canvas. The stick is placed across the ditch with the canvas up stream where it is weighted down with a few shovelfuls of earth. This is more substantial than an earth dam and is easy to move.

The water is led out over the land next to the ditch in small rills, through breaks made with a hoe or small shovel, until it is all absorbed. The distance to which it can be carried will depend on the slope, the porosity of the soil and the flow of water available. As each area is sufficiently watered, the dam is moved down the ditch and the operation repeated until the field is covered. One man can irrigate from 5 to 10 acres per day by this method.

FURROW IRRIGATION. By the furrow system the water is led out from the supply ditch on the upper side of the field. Usually it is carried in secondary ditches to the head of parallel furrows leading down the slope. If the ground is irregular the supply ditch may be carried across the slope at a low grade and the furrows arranged across it down the slope at a moderate angle. The supply ditch is tapped opposite each furrow and the water permitted to flow until the soil is sufficiently wet. The practice of constructing underground pipes with frequent rises, in which to distribute water to the furrows is increasing.

This method is applicable to all cultivated crops planted in rows, and to orchards, vines, and bushes having an orderly arrangement. The water may be turned down every row or every alternate row as in the case of strawberry fields, especially at fruiting time, and potato fields. As the latter crop approaches maturity, it is particularly important that all the soil in the rows be not permitted to become wet.

In orchards where the furrow system is the most common method of applying water, 2 or 3 furrows may be run between each 2 rows of trees. If the trees are small the furrows may be near them; if large, the furrows should be near the middle of the interval. Either a plow that throws the soil both ways, or, if the soil is loose and soft, a large roller with ridges on its surface may be used to make the irrigation furrows.

Depth and length of furrows. Deep, narrow furrows are more economical of water than shallow, broad ones. Deep trenches reduce the moistening of the soil between the trenches which permits evaporation. The water distributes more rapidly downward than sideways, especially if the soil is fairly porous and uniform.

The length of furrows between supply ditches will depend on the slope of the land and the porosity of the soil. The flow of water and the length of furrow must be adjusted to these two factors. On a steep slope of porous soil, a longer furrow may be employed, that is, fewer supply ditches are necessary, than on the same soil on a flat grade. A large flow of water will somewhat make up for a flat grade or a porous soil. Here, however, troubles with erosion set in. The limits of this adjustment are best learned by practice.

SUBIRRIGATION. This means the application of water below the surface. Soil is sometimes naturally subirrigated by the seepage of water from some nearby slope or by the rise of a spring to the surface. In artificial subirrigation the water is carried from the supply ditch in underground channels of clay tile or concrete conduits. If tile is used the water passes out between the ends of the sections and spreads out into the surrounding soil by seepage and capillary movement. This method is admirable in theory but in practice it can be operated only under a very limited set of conditions. It is very economical of water; it is permanent and does not interfere with the cultivation of the surface.

The outstanding difficulties involved in the method are: (1) that the seepage of water from the joints between the tile into dry soil attracts the roots of plants in that direction, to the extent that they are likely to enter the joints and break up into fibrous masses that clog the tile. (2) The diffusion of water by capillary movement in a dry soil is very slow and the lines of tile must be very close together in order to moisten all the soil. They must also be placed quite close to the surface for the same reason. If the subsoil is porous there is a large downward movement of water.

To avoid this difficulty from roots, concrete conduits without joints but with short risers at frequent intervals have been used in a limited way. At the top of each riser is a cap of cement that is porous or that has holes on the under side from which the water may pass out into the soil.

The first of two sets of conditions where sub-

irrigation is practicable is where the upper soil is very porous so that water will move freely by percolation. Under this porous soil within not less than 3 or 4 feet should be a relatively impervious layer of soil, or it may be a water-table. Water is turned into the tile under a considerable pressure—say a head equivalent to the depth of the pipe in the ground. Under this condition the water passes rapidly out into the soil by percolation and accumulates as a water-table or saturated zone which gradually rises toward the surface as the flow continues. Since this table is nearly level, unless the irrigation pipes are too far apart, the water rises uniformly and when moisture appears at the top of the soil the supply of water is cut off and if possible the pipes are drained to remove the surplus water. The crops then can use only capillary moisture. This method has been used with marked success on muck soil. The pipes should be 20 to 30 feet apart.

The other condition where subirrigation is used is on greenhouse benches where quick-maturing crops are used. The bottom of the bench will hold the water and cause the soil soon to be saturated. The short-growing period of the crop prevents injury by the roots.

In installing pipes for subirrigation, care must be taken to avoid a heavy grade else the water will run to the lower end without wetting the soil around the upper end. In no case should the grade in the tile be equal to more than half the depth of the pipe in the ground, and a third to a quarter of that fall in the length of a line is a better adjustment. The ends of the tile should be separated a fraction of an inch to permit the distribution of water.

SPRAY IRRIGATION. The overhead or spray system leads the water under pressure out over the field in pipes that are placed either on the surface of the ground or on posts a few feet above it. There are two main systems of discharging the water. The first throws it in solid streams from small nozzles placed in a straight line on the discharge pipe at intervals of from 18 to 36 inches. The water is thrown out to a distance of 20 to 30 feet so that the distribution pipes may be from 40 to 60 feet apart, and in lines of several hundred feet in length. At the supply end is a joint and a lever arm with which the pipe can be turned through the arc of a circle. By this means the position of the nozzles relative to the surface of the ground can be changed and the water applied to every part of the strip of land on either side within the range of the nozzles.

By the other system riser pipes of such length that the water is discharged 4 to 6 feet above the surface are placed at intervals on the distribution lines and equipped with spray nozzles. These nozzles may be either of a rotary or a stationary type. The nozzles on lines of pipe lying next one another are staggered so as better to cover the surface. Each nozzle will cover a circle 80 to 100 feet in diameter. Any spray system requires pressure of at least 25 pounds per square inch and 50 pounds is best for good operation. This involves a high reservoir and perhaps a large pumping plant. The expense of installation and maintenance is large, and the amount of water that can be applied is relatively small.

The spray system is an ideal method of applying water to many crops, especially vegetables and small fruits. It is wasteful of water by evaporation but not by seepage. It also is used to protect crops from frost and to reduce injury from freezing. A coat of ice formed on the foliage by applying the spray when the temperature of the air is near the freezing point serves as an admirable protection.

As has been suggested above, both the subirrigation and the spray systems of applying water are best adapted to humid regions where the amount of water applied is usually small. The spray system is adapted to use on rough ground and on any kind of soil.

AMOUNT OF WATER TO APPLY. The amount of water to apply is a matter difficult to state. It depends on (1) the water capacity of the soil, (2) its porosity, (3) the climate, and (4) the crop.

The amount of water required to produce any particular quantity of crop is called the "duty of water." This includes the total amount of water used to produce the crop—both that which passes through the plant and that which is lost from the soil by evaporation and seepage. If the water is carelessly and wastefully handled, the duty of water is much lower—that is, more water is required per unit amount of crop—than where it is carefully handled. For a normal yield of crop the duty of water on the field is the equivalent of from 15 to 30 inches of rainfall. The larger the amount of water that is supplied by summer rainfall or is stored in the soil from winter rainfall, the less is the amount that must be applied in the crop season. The duty of water at the head canal has been found for many irrigation systems in the western United States to be from 3½ to 4 feet per acre. This in connection with the figure for the duty of water on the land shows the large losses that occur.

The critical problem is to keep the soil in the *optimum* or best moisture condition for crop growth. Most fruiting crops, excepting small fruits, do best when the soil becomes rather dry at the time of maturity. Therefore, water is best added during the early stages of growth. If the soil is deep and porous, yet fine enough to hold a large amount of water, it may be practicable to make one large application of water just before or just after the crop is planted. In parts of the Northwest—the eastern Washington wheat

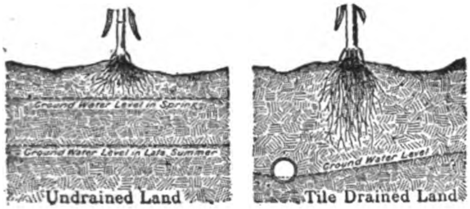


FIG. 28. Plant roots go only as deep as permitted by soil water when at its highest level. The crop on undrained land suffers from drought in midsummer; the crop on well-drained land sends its roots deep and is assured of moisture at all times.

region, for example—a single heavy application of water is made in the early spring before planting when the spring floods from the melting of the snow in the mountains are running. The soil is then used as a storage reservoir.

The amount of water that can safely be applied at any one time depends upon the depth and storage capacity of the soil and its dryness at the time of irrigation. Reference to the moisture capacity of soils (p. 21) shows that a 3-foot section of sandy and silt loam soils will absorb without leaching from 10 to 12 inches of rainfall. Assume that the soil already contains one third of that amount, which is probably low, then the storage capacity of that section is found to be 7 to 9 inches. But in arid regions one is not confined to the surface 3 feet of soil in which to store moisture for the use of crops. It has been clearly shown by investigations in Utah and other states that a 6- or 8-foot section may readily be used. Therefore, twice that amount of water, or 14 to 18 inches, might be added. If the soil were only half reduced in moisture, then it would be possible to apply from 10 to 15 inches of water at one application if it were added gradually.

There are usually physical difficulties in the way of applying this amount of water at one time. The topsoil becomes too wet; the system takes too much time; and besides, it is unusual for the entire section of soil to become so much reduced where application is made two or three times a season.

IRRIGATION DETAILS. Relatively large rather than small applications of water should be made. Where the soil is dry, if only a small application is made, it does not sink deeply into the soil and is quickly lost by evaporation. Irrigation water should be stored below the surface 6 inches of soil. A fair application of water at any one time is from 4 to 8 inches. Gravelly soils and moist soils take the smaller, and sandy and silt soils the greater amounts.

Two or three applications are usually made in a season. Clay soils are best irrigated before planting, when they should have a thorough wetting so that the moisture will reach a depth of several feet. When this moisture has become distributed so that the surface soil can be worked without puddling, it should be fitted and seeded and the crop grown on the water stored. Water is best applied at night or on days when the sky is cloudy and the atmosphere moist and when the water can seep into the soil to the point where tillage is possible. Puddling and baking are thereby reduced. If crops are on the ground there is less danger from scalding injury caused by warm water in contact with the tissues.

Irrigation in humid regions. Irrigation is more difficult to carry on successfully in humid than in arid regions. There is always the possibility that a rain may follow immediately after an application of water; unles the soil is either naturally or artificially well drained, there may then be injury from wetness. For this reason irrigation in humid regions is safe only on rather light soils.

The practicability of irrigation in humid regions is much limited. As a general principle, it may be said that it is permissible only under the following combination of conditions: (1) a light, porous, but fertile soil; (2) where the crops grown have a high acre value such as vegetables; (3) where the crops are rather shallow-rooted; or (4) where the product is particularly sensitive to dry weather. This applies to crops like lettuce, onions, wrapper tobacco, celery, small and bush fruits.

There are many small irrigation systems in the eastern United States mostly under such conditions as described above. Some irrigation is practised in the humid parts of Europe where much grassland receives water —some of it in the form of sewage.

Land Drainage

Drainage as a phase of soil management is the art of removing surplus water. It has been pointed out in a preceding chapter that any moisture in the soil that is not held permanently in capillary films between the soil particles is surplus or excess moisture, and that its presence is injurious to the productive capacity of the soil. Such water is free to flow away under the action of the force of gravity and any method by which it is assisted to flow out of the root zone constitutes drainage.

FIG. 29. The result of tile-draining. The yields of oats from an acre of undrained (*at left*) and drained red clay soil. (Wis. Bul. 199)

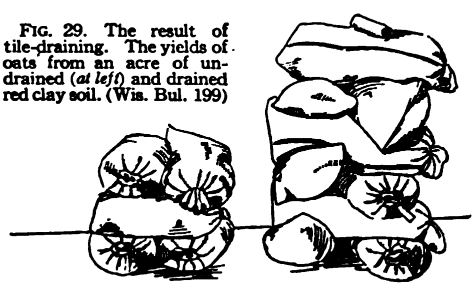


FIG. 30. An open ditch wastes lands, hinders tillage, and only partly effects the desired results.

There is very little land in humid regions that would not be benefited, that is, enabled to produce larger crops, by drainage. In almost any state or province of the North American Continent, it is safe to say that 80 per cent of the farm land needs more or less drainage and 50 per cent will certainly give profitable returns from its installation. If the entire area is not wet, at least there are many wet spots which make the problem very much the same as if all the area were wet. Even irrigated land requires drainage as will be shown later in discussing the improvement of alkali soils.

Effect of drainage. The removal of surplus water seems such a simple operation that its far-reaching effects on the soil's productive capacity are often overlooked. The truth is that adequate drainage may be regarded as the foundation of efficient soil management. So long ago as two centuries before Christ, Cato the ancient agricultural writer, in his directions for husbandry, strongly emphasized the importance of thorough drainage of the soil.

We may list 12 direct effects of the drainage of wet soil as follows:

1. It improves the tilth and firmness of the soil, reducing the tendency to puddle, and permitting the development of the granular or crumby structure.

2. It improves the ventilation of the soil by permitting air to enter the larger soil spaces previously filled with water. Air, of course, is vitally necessary for the growth of plants.

3. It makes the soil warmer by making the heat of the sun more effective so that it keeps at a higher level the average temperature of the soil. This may mean a difference of 10 to 15 degrees.

4. It permits plant roots to penetrate deeper into the soil, because of the better ventilation.

5. More moisture is available to the crop because of the improved physical condition of the soil and the deeper rooting of the crop.

6. Heaving is reduced if not entirely prevented. It is the surplus water that causes the damage when a soil freezes. A drained soil is porous and spongy and takes up within its pores the expansion of the film water in freezing.

7. The activity of beneficial organisms in the soil is increased. The organisms that cause decay and those that change and fix nitrogen require good ventilation, and a fairly warm temperature, both of which result from drainage.

8. The supply of available plant-food is increased by the higher temperature, better moisture conditions, deeper root penetration and greater activity of the soil organisms.

9. Through its many effects on the physical condition of the soil, drainage improves the sanitary condition of the soil and prevents the accumulation of toxic materials. In arid regions it removes the excess of soluble salts known as alkali.

10. The efficiency of all kinds of farm machinery is increased. The land can be worked more days in the year; teams and tools can go upon it more days in the year; crops develop and mature more uniformly and, therefore, can be harvested with a smaller loss.

11. The average length of the season is increased because the land can be prepared and planted earlier in the spring.

12. Erosion is reduced as a result of the removal of the surplus water below the surface under suitable conditions where it causes no damage.

METHODS OF DRAINAGE. Many methods have been and are used to secure drainage. The florist places a few pebbles in the bottom of the pot before filling it with soil; Cato recommended the use of bundles of faggots placed in trenches; shallow surface ditches or furrows have been widely used; pioneers in the northeastern states used stone, poles, brush, and plank boxes. Whatever the method and materials, they are to be rated according to their capacity to remove the water from the soil. They are practicable in proportion to their cost, convenience of construction, and permanency of operation. All those mentioned have advantages under some conditions.

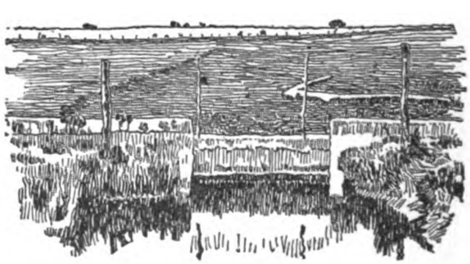


FIG. 31. A system of underdrains leaves the surface unbroken, saves time and labor, and keeps the soil in better condition

Drains may be divided into two types: (1) open or surface drains and (2) covered or underdrains.

Open Drains. These are used when the volume of water to be moved is very large; where the grade is very slight; where temporary results are desired; where covered drains cannot be easily constructed or maintained. There are many objections to them: They occupy much land; they obstruct the surface and greatly interfere with all farm operations; they are costly to maintain; the banks are likely to be a nursery for weeds; and finally the shallow channels that are used to drain the interior of fields are very inefficient.

Underdrains. These are the best means for the interior drainage of farm land. Modern underdrainage is done almost entirely with tile; there are very few conditions where stone, poles, brush, or timber boxes are justified. Where stones cannot otherwise be disposed of they may be put in ditches to give such drainage as they afford, but these like the other materials mentioned make channels that are not sufficiently permanent. While such ditches may give very useful service, tile will do much better. The first cost of construction is usually no higher, if as high, for tile than for these other materials if the extra labor is considered. Tile drains do not obstruct the surface of the land; they lower the water well below the surface and thereby make a root zone of good depth; for small ditches they make the best use of the grade since they provide a smooth, even channel; and their cost of maintenance is very small. Tile can be made to operate in any kind of soil and under almost any condition of crop and water-table. Water enters at the joints between the sections which, in sizes below 10 inches in diameter, are usually 12 to 13 inches long. Above that diameter they are usually 2 feet in length.

Arrangement of drains. This should be determined by the character of the soil, the cause of the wetness and the slope of the land. The aim is to place the drains in such a way as to remove the water in the most direct and at the same time in the most economical manner. Several types of conditions may be mentioned:

1. Any land that is uniformly wet requires a system of drains at regular intervals. Clay soil being very impervious requires drains rather close together. Depending on the crop to which the land is devoted, they may be 2 to 4 rods apart. They should also be relatively shallow; from 2 to 3 feet is the common depth. Soil with a hardpan within 5 feet must be drained according to the character of the soil above that layer. Down to 3 feet the tile should be placed on the surface of the hardpan or in a shallow trough in its surface and not be buried in the hardpan. Tile should also be kept at the top of the hardpan up to within 20 inches of the surface. If the hardpan is a thin layer near the surface, it may be practicable to drain the land by breaking up this layer with an explosive (p. 41) after which tile may be placed at a depth of about 3 feet. Sandy, gravelly, and porous silt soil may have the lines of tile placed 2 to 3 times as far apart as that in clay soil.

2. Springs should be drained by tile running through their centres or along their upper edges and cutting down if possible to the impervious layer which is usually the cause of their appearance. Often short wing drains extending to right and left will better collect the seepage.

3. Seepy lines and areas of wetness at one general level on a slope are usually drained by a ditch along their upper edge which should cut fairly deep. If the wet zone is wide, two or more parallel lines across the slope may be necessary. Begin at the upper side.

4. A few wet pockets and irregular sags may be drained by lines of tile run to or through them in the most direct manner possible consistent with the grade.

From 2 to 3½ feet is the common depth for drainage. In cold regions no attempt is made to avoid the zone that freezes, as tile are very little injured if of good quality. It is very unusual for tiles to freeze full of water.

Capacity of tiles. The capacity of tile depends on its size and grade. It varies directly with the square of the diameter and with the grade but the variation is not regular for changes in size or in grade. An 8-inch tile on a grade of 1 foot per 100 feet will carry 7½ times as much water as a 4-inch tile on the same grade; a 6-inch tile will carry 3½ times as much as the 4-inch. A change in grade of from 1 foot to 3 feet in 100 feet in a 4-inch tile nearly doubles its capacity. In a 6-inch tile the same change in grade increases the capactiy by ⅔.

Coefficients of drainage. The area of land that may be drained by a tile of a given size depends on the grade of the latter and on the amount of surplus water due to springs and steep surface slopes. In regions where the annual rainfall is from 35 to 45 inches and the maximum fall in any 24-hour period is not over 2 inches, it is customary to use a tile that will remove ¼ of an inch of water over the area in 24 hours. This ¼ inch is called the drainage coefficient. Where the annual rainfall or the maximum daily fall is larger, a coefficient of ½ inch is used. Where the slopes are steep, springs are common, or the surface soil particularly impervious, especially if situated on a good slope, the larger coefficient must be used. It is seldom that a coefficient of ¾ of an inch is required.

Tile do not operate under pressure and there is a large variation in the flow in drains. It is never necessary to provide for the maxi-

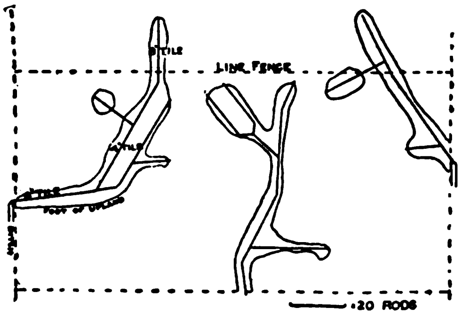


FIG. 32. Tile drainage of this 80-acre field raised its value $1000. Good farmers and good neighbors do not let a line fence stand in the way of such improvement. (Wis. Bulletin 229).

mum fall of rain for the soil acts as a sponge to hold back a large part of any single shower. Calculations as to the size of tile needed must be supplemented by sound judgment based on experience with problems of this kind. Engineers without agricultural experience should not be entrusted with important agricultural drainage projects.

LEGAL ASPECTS OF DRAINAGE. Many problems arise in every community of small farms concerning one's rights to an outlet across a neighbor's land and the distribution of responsibility for the construction and maintenance of ditches. A few general principles that are very widely recognized by law-making bodies and by the courts may be stated to aid one in reaching a decision in such cases.

1. Land at a lower level in the natural direction of drainage must receive the water from above and the owner of the lower lying land is liable for damage caused if the flow of this water is obstructed. On this principle a land owner may not build a levee to keep the drainage water from coming down from the land above; and public highways and railroads are obliged to provide reasonable channels for the movement of the natural drainage of the country traversed.

2. Society recognizes that the drainage of wet land for agricultural purposes increases production and is a public as well as a private benefit. The laws of nearly all states, therefore, aim to permit a land owner to secure any reasonable outlet by drainage across the property of adjoining owners. One owner can compel another to let him have a right of way for necessary outlet ditches. The method of securing this privilege is stipulated in the statutes and is designed to safeguard the vested property rights of the man disturbed.

3. The cost of improving land for agricultural purposes by drainage is assessed against the land benefited in proportion to that benefit so far as it can be assigned by a board of judges or assessors. Where a tract

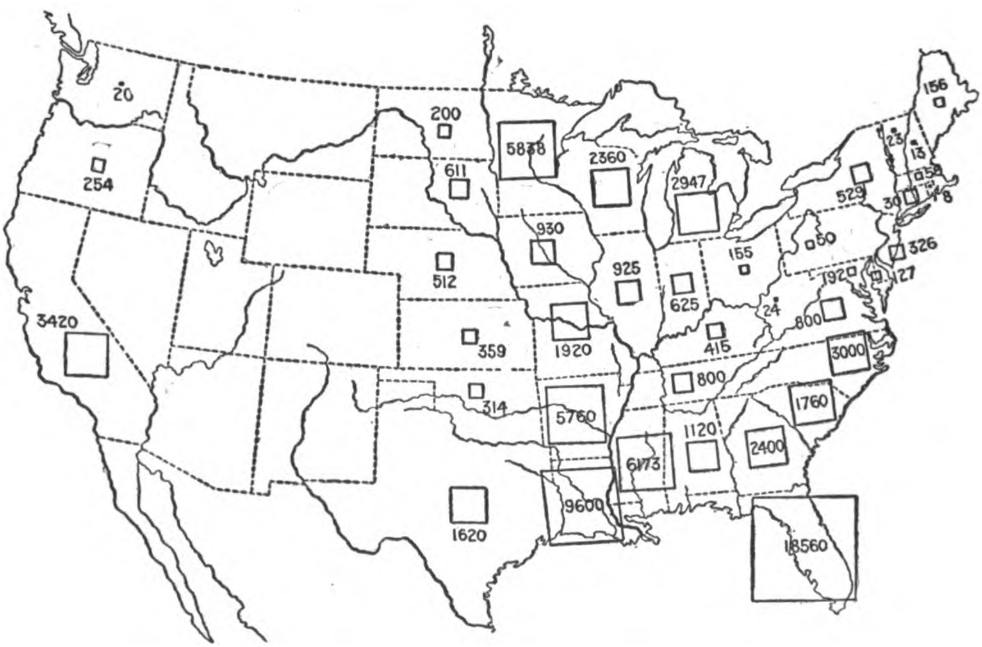


FIG. 33. There are 79,005,023 acres of swamp land in the United States, a large part of which could, should, and probably will some day be drained and made productive. The squares show the relative amounts in the various states. The figures are thousands; that is, 000 should be added in every case. (U. S. Chamber of Commerce)

of wet land can be drained only by cutting a ditch across adjoining land that does not need drainage, the entire cost, including damages, must be assessed against the owner of the tract of wet land.

Legal provisions for drainage. Where a number of owners of wet land must act together to secure drainage, the laws of many states provide an arrangement by which they can come together either wholly or in part voluntary, have the necessary surveys made, rights of way secured, construction carried out, and the assessments distributed by a special or drainage commission under the general supervision of the local courts. An area of land so organized constitutes a "drainage district." It may be authorized to issue bonds to finance the improvement, and the collection of the funds to liquidate these may be distributed over a long period of years and collected in the same manner as taxes.

History of underdrainage. The art of land drainage is somewhat familiar to all improved parts of the world and the practice of tile drainage is common over wide areas. The use of clay pipes for drainage is not much more than 200 years old and seems to have been first practised in a monastery garden in France. About 100 years later a similar practice began in England. About 1835 the first tile drains were laid in America. Some doubt exists as to whether they were first placed by John Johnston on his farm near Geneva, New York, or by an English consul in the coast region of Virginia. At any rate the work of Johnston is best known and continues to be a splendid object lesson in the possibilities of land improvement by means of tile drains. The drains constructed at that early date are still in active operation and the farm is widely known for its productiveness.

Thousands of miles of tile drains have since been constructed in the North Central and the Middle Atlantic states, and the practice is now rapidly spreading into the humid sections of the Southern states where it is much needed over large areas.

Drainage of irrigated land. The practice of underdrainage is now becoming common in irrigated regions where the rise of alkali is a menace. The most feasible method of permanently removing that material from the soil is found to be heavy irrigation coupled with a rather deep system of drains—4 to 5 or even 6 feet below the surface. The system should be deep enough to clear a good depth of soil of the alkali and also deep enough so that the lowering of the moisture content in the surface soil will permit very little evaporation. Owing to the loose and often quicksand qualities of much of the soil impregnated with alkali, there is often much difficulty from the filling of the tile with sediment. For this reason wooden boxes are frequently recommended in place of tile for drainage purposes.

Explosives in Soil Improvement

Explosives are used for 3 types of soil improvement: (1) in constructing open ditches; (2) in breaking up impervious soil to facilitate the movement of water; and (3) in breaking up stones and stumps in land clearing.

For drainage. The direct effectiveness of explosives for draining the soil is very limited though it has been much advocated. Where a thin layer of impervious soil is underlaid by porous soil, explosives may be employed to break up the impervious layer and permit the surplus water to distribute itself through a greater depth and perhaps drain away below. Explosives in a deep soil that is all of the same impervious quality are of very little service in removing any large excess of water, such as usually requires underdrains.

Explosives for opening trenches. Though explosives cannot be used where tile are to be placed, in building open ditches they loosen up the earth, break up obstructions such as stones and stumps, and may be used to throw the earth bodily out of the course of the ditch. They are especially useful for this purpose where the earth is very hard and stony or rooty. Wet soil operates best. Charges of a stick of dynamite each are placed every 18 to 36 inches at a point just above the proposed finished grade of the ditch. All the charges in a considerable line are fired at one time with an electric exploder. The charge lifts the earth into the air with tremendous force and if there is a good wind blowing from one side most of the material falls clear of the ditch and a very good channel is formed which may be given a little finishing with other tools. In stream channels that have a good grade and that carry water, the flow of the water may be depended upon to finish the channel.

For tillage. Explosives may be used as a means of tillage where the subsoil is hard and impervious, and where they take the place of subsoiling implements. Small charges (a half stick of dynamite each) are placed 2 or 3 feet deep at intervals of 10 to 15 feet.

FIG. 34. **One way to stop or prevent erosion is to keep sloping land planted to a permanent crop, such as trees**

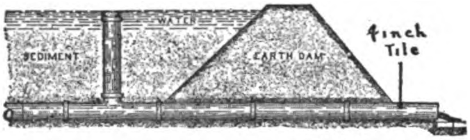


FIG. 35. An effective device for filling in an eroded gully. It consists of an earth dam and a tile running through it, carrying a riser through which the water seeps away, leaving the sediment to settle and fill the ditch.

The explosions then shatter the soil but should not throw it out of place so as to cause craters, and the loosening effect hastens the movement of water. Where the soil is particularly wet, the use of the explosive should be supplemented by underdrains placed between the lines of charges to carry off the surplus water.

The use of explosives in setting trees in hard soil not only loosens the soil but also partly makes the excavation. If the soil involved is made up of hard streaks alternating with porous layers large benefit may be secured. Where used merely to break up the soil, the lower strength (40 per cent) dynamite is found best as more time is given for the spread of the shock and less soil is thrown out of place. For ditching and for breaking up stone it is frequently better to use the higher grades of quicker explosive force. (See Volume 3, Chapter 27).

The Control of Erosion

Erosion, or the cutting away of the soil, is controlled by regulating the flow of the water and by forming channels in which it can run and do very little damage. The flow of water is regulated by the construction of side-hill ditches or terraces, which make necessary "contour farming."

Side-hill ditches. Side-hill ditches consist of trenches across the face of the hill made by throwing up a ridge. They have a moderate fall so that the water passes off slowly without serious cutting. The grade should not be more than a half inch per rod or 3 inches per 100 feet else the flow is likely to be so rapid that serious cutting will ensue. The frequency of these ditches on the hill must be determined by the slope of the land and the porosity of the soil. The steeper the hill and the more impervious the soil the closer they must be. They may be used on slopes up to 15 or 20 feet fall per 100. Ordinarily they are made 2 to 4 rods apart. They are objectionable because they occupy useful ground and interfere with all cultural operations.

FIG. 36. A simpler way to fill a smaller gully is with a dam of logs and brush

Terraces. Terraces are of two types: (1) the flat terrace and (2) the falling terrace. In the flat terrace system, the land is graded into a series of benches or broad, gently sloping terraces, each of the same elevation, the limit of the terrace being marked by an abrupt drop to the next level. The flow of water is checked with the expectation that it will all be absorbed by the soil. Each level must be cultivated separately and there is much inconvenience and considerable waste of land under this system. But it is adapted to very steep land where very intensive cropping is practised.

The more popular form is the falling or Mangum terrace which differs from the flat terrace in that each level has a gentle fall in one direction. It differs from the side-hill ditch system in that the ridge and the trench are so broad and flat that cropping and tillage may be carried on over the entire area making it a permanent improvement. The falling terrace is adapted to land having a fall up to 15 feet per 100. The ridge and the trench are each from 8 to 10 feet wide and the grade of the trench is from three quarters of an inch to 1½ inches per rod, or about 6 inches per 100 feet. The aim is to impede the flow of water by spreading it out in a thin sheet and insure the maximum absorption. At the same time any surplus water is led off the field so gently that no cutting occurs.

The frequency of the terraces is such that the vertical distance between them is 4 to 5 feet. They would thus be farther apart on a gentle than on a steep slope. The width of the ridge is from 1 to 2 rods.

For any system of terraces the land must be surveyed and the position of the terrace ridges staked at intervals of 50 feet. The fall between stakes may also be marked. With these lines of stakes as a base, furrows are thrown toward the stakes for a distance of 5 to 6 feet on either side. A terrace drag or a road grader is then used to further move the earth toward the stakes and form the ridge. After dragging, another series of furrows is turned again beginning at the stakes and extending 2 or 3 furrows farther out on each side, when the drag is again used. Where high terraces are to be built, 2 or 3 years may be required to work them up. Where deep gullies are crossed, a dam is constructed on the lines of the ridge. Beneath this is placed a tile drain with the upper end blocked but with a riser pipe reaching up to the grade

of the terrace trench. The drainage water and sediment from above accumulate in this basin; the clean water is drawn off over the top and into the tile; and the sediment gradually fills in the gulley and makes the surface of the land smooth.

An aid to all forms of terraces is the deep tillage of the land on lines of equal elevation or contours. Each little ridge formed by the tillage operations serves as a small check to the flow of the water.

Cover crops and humus. Any treatment of the soil that increases its capacity to absorb and retain water aids in checking erosion. Practices that serve this end are deep plowing and the incorporation of organic matter. Cover crops during the season when the land would otherwise be bare are helpful and tile underdrains help by drawing off the water below in channels that resist erosion. Underdrains are especially serviceable where erosion occurs by seepage at a considerable depth below the surface coupled with the caving in of the topsoil. These methods are all adapted to land having a slope of less than 10 feet per 100. Very steep slopes, and land of a fine sand to silty texture that is especially susceptible to erosion, should be kept permanently in fine-rooted grasses or timber, perhaps with terraces in addition. Terrace farming is most practised in all those warm regions of the world where there are heavy winter rains without appreciable freezing of the soil.

FORMATION OF HUMUS

Favorable Conditions	Unfavorable Conditions
1. Moist Soil	1. Saturated Soil or Dry Soil
2. Warm Soil— 50° 90°	2. Cold Soil
3. Some Air	3. Baked or Crusted Soil
4. Presence of Lime	4. Sour Soil
5. Bacteria	

FIG. 37. Courtesy International Harvester Company

Maintenance of Organic Matter

The supply of organic matter in the soil must be maintained at a fair level. This is accomplished by preserving and returning to the soil the crop residues—the roots and stubble and as much more of the crop as may be practicable; by the application of animal manures and organic fertilizers; and by the turning under of crops grown as manures.

Crop residues. No crop is removed in its entirety from the soil. The roots, straw, leaves, or part of the husks are discarded, remain with the soil and add to its supply of organic matter. The roots amount to $\frac{1}{6}$ to $\frac{1}{4}$ of the total growth. Even hay crops leave $\frac{1}{3}$ of their total growth on the land. Naturally any practice that destroys this material, such as burning straw and leaves, or permitting piles of straw, pea vines, sugar-cane leaves, etc., to rot, and all similar waste, is sharply condemned. The dry matter in these materials has a commercial value of from $2 to $4 per ton for manurial purposes totally aside from its content of plant nutrients.

It is part of good soil management to conserve these by-products for the sake of the organic matter as well as the plant nutrients they contain. There should be a studied arrangement of crops and their products sold that the greatest possible amount of by-products may be returned to the soil.

Crop rotation. A rotation may be defined as a studied succession of crops designed to increase their yields and the ease of caring for them. It is beneficial for many reasons, not the least of which is because the practice increases the total amount of organic matter returned to the soil. The growth of a succession of different crops gives a larger yield over a period of years than the continuous growth of the same crop. An important feature of such a succession is that there shall be included crops of a widely different type. Those that require tillage are combined with those that do not; legumes with non-legumes; winter crops with summer crops; deep-rooting crops with those that are shallow-rooted; those that do not require a sweet soil with those that require a lime-rich soil. The following are some of the more common combinations in use:

Canadian four-course
1. Potatoes, corn, barley, oats, peas, mangels, or rutabagas.
2. Fall-sown wheat or spring-sown oats or barley seeded to clover and timothy.
3. Meadow, clover.
4. Meadow or pasture, clover and timothy.

English Norfolk four-course
1. Turnips, fed on land to sheep.
2. Barley seeded to clover.
3. Clover hay.
4. Wheat.

Common North England five-course
1. Wheat or oats.
2. Turnips and potatoes, part in each.
3. Barley or oats, seeded to clover.
4. Clover, meadow.
5. Timothy and clover meadow or pasture.

New York five-course
1. Beans, mangels, cabbage, corn for silage, part in several crops.
2. Oats, seeded to clover and timothy.
3. Meadow, clover.
4. Meadow, clover, and timothy.
5. Meadow or pasture, timothy.

New York three-course
1. Beans.
2. Wheat, seeded to clover.
3. Clover.

T. B. Terry three-course
1. Potatoes.
2. Wheat, seeded to clover.
3. Clover.

Cornell four-course, dairy
1. Corn (manured) for silage.
2. Oats.
3. Wheat (manured) seeded to clover and timothy.
4. Clover cut twice.

Ohio five-course
1. Corn (manured).
2. Wheat, seeded to clover and timothy.
3. Meadow, clover.
4. Meadow, timothy and clover.
5. Pasture.

Corn belt five-course

1, 2, and 3. Corn, grain, and silage.

4. Oats or wheat, seeded to clover.
5. Clover hay, part plowed for corn.

Tennessee five-course
1. Cowpeas followed by rye plowed under in spring.
2. Cowpeas.
3. Corn.
4. Wheat seeded to clover or cowpeas.
5. Clover or cowpeas.

Cotton four-course
1. 2, Cotton.
3. Corn and cowpeas.
4. Oats with cowpeas.

Virginia two-course.
1. Potatoes followed by corn.
2. Oats followed by cowpeas.

Virginia five-course
1. Corn.
2. Wheat, seeded to clover.
3. Clover.
4. Wheat, seeded to clover.
5. Oats or pasture.

North Carolina four-course
1. Corn with cowpeas.
2. Peanuts.
3. and 4. Cotton.

The advantages of a carefully arranged rotation of crops may be listed as follows:

1. The land is more completely occupied and protected by a succession of crops that grow in summer, fall and winter.
2. Weeds are better controlled by the tillage of some crops and the smothering effects of the leaves of others.
3. Some crops prepare the soil for those that are to follow: for example, corn for wheat, and wheat for clover.
4. The succession of different crops aids in the control of plant diseases and insect pests.
5. The labor is more evenly distributed than under continuous cropping.
6. Larger crop residues build up the organic matter of the soil.
7. Legumes in the rotation aid in the maintenance of the available supply of nitrogen.
8. Crops differ in their effects on soil structure. The bad effects of some are offset by the beneficial effects of others.
9. Loss of plant-food by leaching and washing is reduced by the more continuous use of the soil.

1—HELPS MAINTAIN SOIL FERTILITY

2—IMPROVES PHYSICAL CONDITION OF SOIL

3—COMBATS WEEDS, INSECTS AND PLANT DISEASES

4—PREVENTS WASHING OF SOIL

5—FURNISHES A VARIETY OF FEED

6—DISTRIBUTES FARM WORK THRUOUT THE YEAR

7—LEADS TO LIVE STOCK FARMING

8—INSURES AGAINST CROP FAILURE

9—MEANS LIVING ON THE FARM

FIG. 38. Nine ways in which crop rotation is profitable. (Courtesy International Harvester Company)

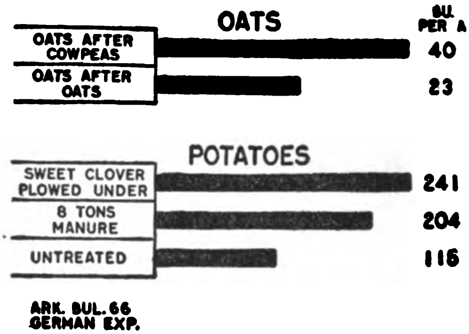


FIG. 39. The effect of legumes—both in a rotation and plowed under—future crops raised on the same land. (Courtesy International Harvester Company).

10. The bad sanitary effect of one crop is overcome or corrected through the introduction of a different type of plant.

Legumes. Closely allied with a rotation of crops is the inclusion of legumes in the crop succession. By this means the supply of nitrogen in the soil is better maintained, and thereby the production of organic matter is increased. This is true only when the legume is inoculated with the bacteria that produce knots or nodules on the roots and which are able to use the free nitrogen of the air which the crops themselves can not use. These bacteria leave the nitrogen they have captured in such form that the leguminous and other crops in the rotation can use it.

Inoculation of legumes. Where a legume new to the region is grown, the proper bacteria to produce nodules may not be present. Each variety of legume has its own particular variety of bacteria and if this is not present in the soil it must be added artificially to secure the best results. The addition of suitable bacteria is called *inoculation.* It may be accomplished by applying 200 or 300 pounds of surface soil (the first six inches may be used) from a field where the legume to be raised has grown and developed nodules. This should be spread over the new field preferably in the evening or on a dull day and immediately harrowed in.

Another method of inoculating the soil is to secure from some bacteriological laboratory pure cultures of the desired organism, either in a liquid media or in such form as has been found suitable for the transfer of that organism. These cultures are put up by certain government laboratories and by several commercial laboratories in packages sufficient for an acre or two with directions for their use. These usually indicate that the culture is to be mixed either with the seed or with a certain amount of soil and distributed on the land. These cultures can now be made and handled in very dependable form. Where the soil conditions are favorable for the growth of both the crop and the culture,

one treatment is sufficient; but unless the soil is in favorable condition no amount of inoculation will bring success with the crop. By planting a legume on a new soil for several years without inoculation, a good stock of organisms may be developed from the few that stick to the seed. Seeding a little alfalfa in timothy meadows for 2 or 3 years before planting entirely to alfalfa has this result.

Farm Manure

BARNYARD MANURE. The manure of animals is an important source of organic matter for the soil. When animals consume feed they destroy from one half to two thirds of the organic matter it contains. The remainder is voided and as manure may be used on the soil. In addition to the organic matter, manure contains a large part of the plant nutrients, the nitrogen, phosphorous, sulphur, and potassium in the entire feed consumed. These two groups of constituents make up the chief value of manure for the improvement of the soil.

The following table gives the amount, composition and value of manure produced by 1,000 pounds' live weight of different animals:

COMPOSITION AND VALUE OF THE MANURE OF FARM ANIMALS PER 1,000 POUNDS OF LIVE WEIGHT

Manure		Lbs. produced per year	Organic Matter		Nitrogen		Phosphoric Acid *		Potash †		Commercial Value ‡			
			%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	Plant Foods	Organic Matter	Total	Per Ton
Horse	Urine	4,000	10	400	1.3	52	Trace		1.2	48	$10.30	$ .80	$11.10	$5.50
	Dung	14,500	30	4,350	0.55	80	0.37	44	0.4	58	16.70	8.70	25.40	3.45
	Total	18,500	26	4,750	0.72	132	0.27	50	0.57	106	27.00	9.50	36.50	3.85
Cow	Urine	8,000	7	560	0.8	64	Trace		1.0	80	13.60	1.10	14.70	3.65
	Dung	18,000	20	3,600	0.35	63	0.2	36	0.75	45	13.10	7.20	20.30	2.25
	Total	26,000	16	4,160	0.49	127	0.15	40	0.48	125	26.70	8.30	35.00	2.70
Pig	Urine	12,000	4	480	0.5	60	0.01	12	0.6	72	13.10	.95	14.05	2.35
	Dung	18,000	22	3,960	0.3	54	0.25	45	0.3	54	12.60	7.90	20.50	2.25
	Total	30,000	15	4,440	0.38	114	0.19	57	0.42	126	25.70	8.85	34.55	2.30
Sheep	Urine	4,500	13	585	1.5	68	0.05	23	1.8	57	14.00	1.20	15.20	6.80
	Dung	8,500	45	3,825	0.8	68	0.4	34	0.5	43	13.75	7.65	21.40	5.00
	Total	13,000	34	4,410	1.05	136	0.44	57	0.77	100	27.75	8.85	36.60	5.65
Hen	Total	10,000	45	4,500	1.3	130	0.8	80	0.9	90	27.20	9.00	36.20	7.25

*To convert figures for phosphoric acid into terms of phosphorus multiply by 0.4356. †To convert figures for potash into terms of potassium multiply by 0.832. ‡Nitrogen is valued at 15 cents per pound; phosphoric acid at 4 cents; potash at 5 cents; and organic matter at 20 cents per 100 pounds.

From this table it appears that 1,000 pounds live weight of animal returns in the manure from 2 to 2¼ tons of organic matter annually. To this may be added about 125 pounds of nitrogen, 60 pounds of phosphoric acid and 100 pounds of potash. The annual value of the manure of that weight of animal is about $36 when the organic matter is valued at 20 cents per 100 pounds and nitrogen at 15 cents, phosphoric acid at 4 cents, and potash at 5 cents per pound respectively—which were approximate figures before the war. On this basis about a quarter of the value of the material is due to the organic matter. The urine constitutes about three sevenths of the total value of the material.

The waste of manure. Farmers are not able to take advantage of the full value of the manure; they can not save all the material for the use of crops. The loss in handling may be very large, attaining one half or more of the organic matter, nitrogen, and potash and one third of the phosphoric acid.

The organic matter is lost mostly by decay which has already started actively in the digestive tract of the animal and continues after the material is voided. The rate of decay is promoted by a loose, open condition and by the presence of a moderate amount of moisture. The manure of horses, sheep, and poultry has those favorable physical characters and is most subject to decay. The heating and bleaching of horse manure, known as "fire fanging," is an example of the process. The heavy cold manure of the cow and pig undergo decay more slowly. One third of the organic matter is lost by 3 months decay of manure, and that represents the

FIG. 40. A slow, laborious, and unprofitable way to spread manure

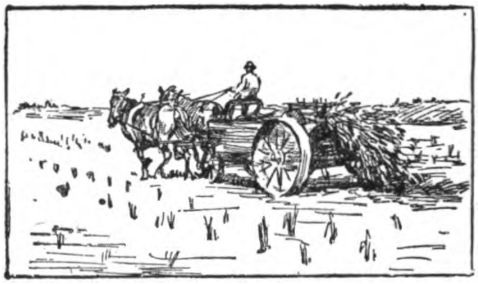


FIG. 41. A rapid, easy, and economical way, good for all seasons

most valuable part. Decay and heating also cause the loss of nitrogen. It is liberated in the form of a gas—ammonia—that passes off into the air. Horse, sheep, and poultry manure are most subject to this loss. Ammonia from the manure is the cause of most of the pungent odor often present in the stable.

The leaching away of the liquid manure and, especially, the leaching through the manure of rain water, cause a large loss of all the soluble constituents since from one third to one half of the valuable constituents of manure are in soluble form.

Conservation of manure. The farmer can prevent a large part of the loss of manure by preserving the liquid on tight floors, in tight drops, in manure pits, and by applying the manure directly to the field. The loss from leaching by rains is largely prevented by keeping the manure (1) under cover, (2) in large piles, and (3) distributed on the land as rapidly as made where the soil absorbs and holds the constituents. The loss by decay may be reduced by keeping the manure saturated with liquid and excluded from the air. Large, dense piles and closely packed pits are essential; small, or low, flat ones are very wasteful.

Where to put manure. The place to apply manure depends on the kind of crops that are being grown; naturally it should be placed on the most profitable crop. All vegetable and forage crops make especially good use of manure. Crops used for their seed or fruit (except corn) respond to the use of manure but are less sensitive to its effects. Topdressings may be made at any time when the growth is not more than 6 inches high; in a rotation they greatly stimulate the hay and benefit the succeeding grain crops. For the growth of vegetable crops, the use of manure may be considered a necessity.

Amount of manure to use must be gauged by the value of the crop. Crops of high acre value such as vegetables and small fruit may well receive from 20 to 50 loads per acre every year or two. When the soil is carefully rotated with legumes that make a good growth, ordinary farm crops can use from 6 to 12 tons per acre once in 2 to 4 years. The smaller the application the larger is the return per ton of manure applied.

Plowing under vs. topdressing. Manure, and the organic matter in particular, is conserved by being plowed under which checks decay and makes it last longer. Topdressing is most wasteful where there is no growing crop on the land; if followed immediately by surface tillage it is likely to give the larger and quicker returns. On a farm carrying a 4- to 6-year rotation, the use of the manure on the 1- and 2-year-old meadows and on the most valuable tilled crop is the best practice; other crops then receive the residual effects. Manure should be kept nearer the surface on wet land than on well-drained land.

Distribution of manure. Distribution of manure is best made with a manure spreader which is more easily loaded and more quickly unloaded than an ordinary wagon. The lighter and more even distribution enables one to cover more acres with the manure and thereby secure a larger yield of crops per ton of manure.

GREEN MANURES. These are crops grown and plowed under entirely for manurial purposes; the use of them is called green manuring. The growing of plants is a process of manufacturing organic matter. For every pound of mineral matter taken from the soil the plant builds up from 30 to 50 pounds of organic substance, made up very largely of the constituents of water and air, which has been shown to have an essential value in maintaining the highest productive capacity of the soil. If the soil is very low in organic matter or if experience has shown that crop residues, and a good rotation with legumes, supplemented by the use of stock manure, if it is available, are not sufficient to keep up the humus content of the soil, then the only recourse is green manuring.

It should be emphasized that the practice of growing crops and feeding them to animals is not the most rapid and often not the most economical method of improving the soil. The reason is that in passing through the animal and under later handling the total loss of the organic matter in the crop inevitably amounts to 65 per cent and may very likely amount to 80 per cent.

In the case of very poor soil, it may be advisable to devote a season or two to the growth of green manure crops. Ordinarily, the better practice is to adjust the rotation so that green manure crops may be sandwiched in between the regular money crops. There are often periods between crops when the soil is not in use and is therefore deteriorating through washing and leaching. When a green manure crop also serves to cover the ground and protect it from washing, it is a cover crop; when it serves especially to conserve available plant-food that might otherwise leach away, it serves as a catch crop.

A special advantage of green manures in soil improvement is the fact that the first products of decay are conserved in the soil. These quickly-formed materials are most useful to the succeeding crop, whereas the latter products of decay are more resistant. This constitutes one of the important differences in value between muck or peat, and livestock and green manure for soil improvement, muck representing the latter stages of decay.

In the choice of a green manure crop the following points must govern the selection: (1) The season when the crop is to grow, whether summer or fall and spring. (2) Whether or not it is a legume. (3) The lime supply of the soil in relation to the green manure crop. (4) The rate and vigor of growth and the hardiness of the plant. (5) The cost of the seed. (6) The relations of the green manure crop with the regular crop. Are they congenial, that is, do they grow well together or succeed each other readily? (7) The ability of the crop to grow in shade. (8) The size of the seed in relation to the moisture supply of the soil at normal planting time. Large seeds can be planted deeper than small ones and are therefore better able to germinate in dry weather. (9) The ability of the crop to withstand severe winter cold and heaving.

Any plant may be used for green manure purposes, regular crops being sometimes plowed under for that purpose. Weeds may be just as useful as crops that must be seeded; indeed some farmers make a regular practice of encouraging the growth of weeds for manurial purposes, especially in orchard management.

Whenever practicable, a legume should be included among the green manure crops although the organic matter supplied by non-leguminous green manures also assists in the process of accumulating available nitrogen from the air. Mixtures of two or more crops usually make better green manure and a larger total growth than plants of one kind. The following crops are most used for green manure purposes:

1. Rye seeded at the rate of 1½ to 2 bushels per acre. It is hardy, survives the winter and reaches suitable size early in spring, and the seed is cheap. It grows on moderately acid soil, but in the early stages of decay is acid and sometimes injurious to crops planted soon after it is turned under.

2. Buckwheat seeded at the rate of 2 to 3 bushels in early summer. It grows on poor soil; its fine roots loosen up hard soils; the seed is cheap and the material undergoes rapid and favorable decay; but it is unsuited to fall and spring growth.

3. Oats or wheat seeded a little heavier than for grain, may be used where the habits of rye do not quite suit the conditions. They are less hardy and mature later in the spring.

4. Rape is hardy on soils fairly well supplied with lime; it may be seeded in either early summer or fall unless the winters are exceedingly open and cold; 5 to 7 pounds of seed are sufficient for an acre, and is inexpensive. The small size makes it quite susceptible to dry weather at seeding time. The growth is massive, watery, and decays more slowly than most other crops.

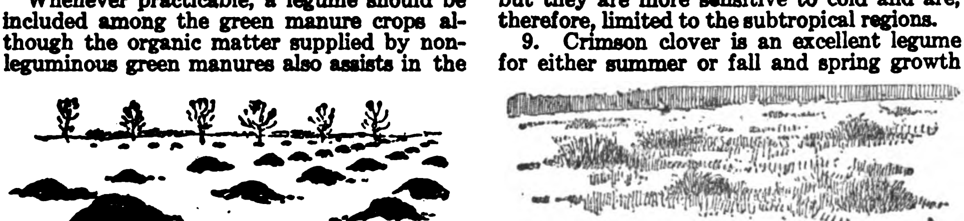
5. Turnips, particularly cowhorn turnips, are in the same class as rape, but less hardy and perhaps a little less favorable in the decay of the material.

6. The cowpea is the leading leguminous green manure crop in warm-temperate regions. A bushel and a half to 2 bushels of seed are used. This being of good size, can be planted deep and is thereby less susceptible to dry weather. In the Northern states it is limited to summer growth on warm, sandy soils. It is not sensitive to a moderately acid soil.

7. Soy beans are in the same class with cowpeas as to climate, soil adaptation, size of seed, and rate of seeding, and are a little more hardy. Their coarse, bushy growth makes them a little more difficult to turn under than cowpeas.

8. The velvet bean and the beggar weed are vigorous-growing legumes, suited to acid soils and in many ways similar to cowpeas; but they are more sensitive to cold and are, therefore, limited to the subtropical regions.

9. Crimson clover is an excellent legume for either summer or fall and spring growth



a b

FIG. 42. The practice of distributing manure in small piles (a) means double work, and uneven soil feeding, giving an undesirable clump of rank growth where each pile lay (b)

FIG. 43. A common but utterly inexcusable way of wasting organic matter is to burn straw stocks. (See Fig. 44.)

up to near the Canadian line. From 15 to 25 pounds of seed per acre are used; being small it must be planted shallow. The crop is moderately sensitive to soil acidity and especially to dry weather at seeding time. In the latitude of New York it is frequently winterkilled.

10. Winter or hairy vetch, seeded in late summer or early fall at the rate of 10 to 25 pounds of seed per acre. It is one of the best green manures for northern sections. The rather large size of the seeds permits deep planting which better enables it to start in dry weather. The dryer the season the larger the amount of seed needed. It is hardy and withstands poor soils; forms large, vigorous nodules; grows late in fall and early in spring; is ready to plow under about the same time as rye; and the fine growth undergoes rapid and favorable decay. It should be planted with some upstanding crop, such as rye.

11. Spring or summer vetch has a larger seed than winter vetch; is not hardy; and makes a smaller growth.

12. Mixtures of rye (3 to 5 pecks) with winter vetch (8 to 15 pounds) are excellent for fall sowing where the spring crop need not be planted before the latter part of May.

13. A mixture of rape (3 to 4 pounds), cow horn turnips (2 to 3 pounds) and crimson clover (6 to 8 pounds) is popular in orchard practice for late summer seeding. The rape and turnips make the fall growth and the rape and clover fill in the early spring.

Many other crops and combinations might be mentioned. The second growth of common red clover or any hay crop may be plowed under, and where the soil is in need of humus this is better practice than to pasture it off.

Some suggestions and precautions in the use of green manure crops should be noted:

1. It is good practice to fertilize the green manure crop, especially with the minerals the soil needs, every pound of which makes possible the growth of 40 to 50 pounds of organic matter. Both the fertilizer and the organic matter are then used by the regular crop.

2. If the soil moisture supply is likely to be short, do not let the green manure crop grow long enough to endanger the prospects of the following crop.

3. A small top may be no fair gauge of the amount of organic matter formed. In the early stages of growth the larger proportion of the organic matter is in the roots.

4. Maturity of green manure crops is not desirable since it produces a woody, resistant condition and a large mass above ground to be turned under at the expense of the deeper root development.

5. The larger the mass of organic matter and the coarser its quality, the deeper it should be plowed under.

6. A large, vigorous growth should be rolled down and chopped up with a disk harrow before being plowed under.

7. When the soil is a little sour the addition of lime immediately after the green manure crop is plowed under is good practice.

8. Seeding a green manure in the latter stages of the regular crop seldom injures the latter and enables the green manure to have a longer period for growth.

9. Advantage should be taken of the preparation of the land for one crop in the seeding of the green manure. For example, clover or vetch may be sown with oats, beans, peas, or corn to be followed by cabbage, late potatoes, or corn. In the case of oats, the seeding is done at planting time; in the other cases, at the last cultivation.

The following rotations illustrate how green manure crops may be used:

1. **Orchard management.** (a) Green manure of buckwheat and crimson clover, or barley and summer vetch, planted by July 15 to be plowed under in fall; or (b) rye and winter vetch; or (c) crimson clover, rape, and cowhorn turnips, seeded by August 15 to be plowed under the following May.

2. (a) Corn for silage, seeded with rye and winter vetch at last cultivation to be plowed under in following May; (b) oats or potatoes; (c) wheat, seeded to clover; (d) clover, second growth turned under.

3. **Corn belt rotation.** (a) Corn, cowpeas, or crimson clover at last cultivation; (b) corn for silage, clover or soy beans at last cultivation; (c) oats, seeded to clover; (d) clover, second crop turned under.

4. Cotton, seeded to cowpeas.

5. (a) Corn, with cowpeas between; (b) oats with cowpeas; (c) cotton seeded to cowpeas or velvet beans; (d) cotton seeded to cowpeas or velvet beans.

Liming

The normal tendency of all soils to accumulate a surplus of acid constituents must be counteracted by the application of some basic material. The acidity may be due either to inorganic or organic substances, or to both

combined. The tolerance of most of the common farm crops for this lack of basic substances, commonly known as soil acidity, is limited.

Any basic material will, to some extent, meet this need. All but 2 or 3 of the basic constituents that might be used to sweeten the soil are unavailable in sufficient quantity, too costly to be used for that purpose, or have supplementary objectionable effects. As a matter of fact just 2 bases are commonly used to square up the balance of the soil, namely calcium and magnesium, which taken together or separately are commonly known as lime. They are abundant; they occur in pure forms widely distributed; they are in suitable chemical combinations; they are economical; and they have very few objectionable effects. Their use, which amounts to the neutralizing of the soil acids is commonly called liming. The more important of the numerous effects of the practice may be listed as follows:

(1) Sweetens the soil and makes it a suitable medium for many crops. (2) Promotes the growth of most legumes. (3) Promotes the growth of nitrogen-fixing and nitrogen-transforming organisms. (4) Promotes the growth of organisms that bring about the desirable type of decay of the soil organic matter. (5) Improves the tilth of the soil. (6) Promotes better drainage. (7) Represses certain disease organisms. (8) Supplies a plant nutrient that improves the quality of many crops.

The common forms of lime and their equivalent strengths of basic materials are shown in the following table:

FORM	SOURCE	POUNDS OF BASIC OXIDES	
		In 100 Pounds	In 1 Ton
Limestone, calcium	Rock strata	56	1,120
Limestone, dolomite, calcium, and magnesium	Rock strata	63	1,260
Marl	Muck swamps	56	1,120
Mussel shells	Mussels	56	1,120
Lump lime	Any of above burned	100	2,000
Ground lime	Lump lime ground	100	2,000
Hydrated lime	Lump lime water slaked	75.6	1,512
Air-slaked lime	Lump or hydrated lime exposed to air	56	1,120*

* Minimum strength. Partially air-slaked material approaches lump lime in composition.

Amount of lime to use. The amount of lime to use on the soil cannot be stated in exact figures. Some soils require as much as 3,000 or 4,000 pounds per acre to satisfy their capacity for bases, but it does not follow that that much must be used to secure a fair growth of many crops; half to two thirds that amount may be sufficient. Similarly, if a soil under treatment needs only 1,000 or 2,000 pounds to satisfy its acids, then 500 to 1,000 pounds may suffice. The amount of lime to apply in any case should be ascertained by some test. For the farmer some of the improved forms of litmus paper tests (p. 91) are most suitable.

The requirements of the crop to be grown also affect the amount of lime needed. A crop that requires a neutral to strongly alkaline soil, such as alfalfa or beets, must receive more lime on an acid soil than a crop that grows in a neutral to moderately acid soil, such as potatoes or oats, or, especially, watermelons or cowpeas.

The limits of tolerance of crops to the presence of an acid or basic reaction in the soil have not been worked out, but Fig. 45 gives an idea of the range of some common crops. As small applications as 300 or 400 pounds of lime carbonate have given marked results on acid-sensitive crops, such as clover, alfalfa, and roots. A fair average application is from 1 to 2 tons of ground limestone or its equivalent for a 4- or 5-year rotation period.

The following general principles may guide one in deciding on the amount of lime to apply:

1. Sandy soils require less lime than clay soils showing the same acid reaction.

2. Soils poor in humus and having a light color are more likely to need lime than dark-

FIG. 44. By spreading and plowing under straw and other waste, much organic matter and plant food is saved

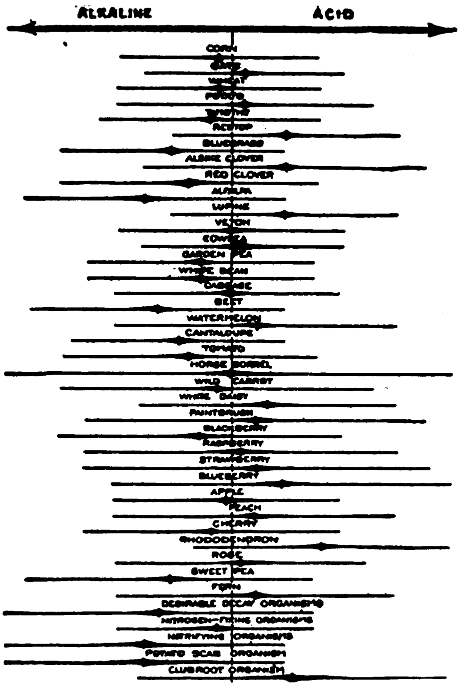


FIG. 45. The line through the centre represents a neutral soil. Each cross line shows the tolerance of a crop to acid and alkali, the broad part marking the condition under which it does the best.

colored soils rich in humus, as shown by a dark color.

3. Glacial soils are less likely to be acid than residual and marine-formed soils.

4. Soils in which limestone fragments may be found are less likely to be acid than others.

5. In sandy soils the subsoil is likely to be more acid than the soil itself.

6. In heavy soils the top soil is likely to be more acid than the subsoil.

7. Crops that are known to require a sweet or basic soil should have a larger application of lime than crops that grow on a neutral or somewhat acid soil.

8. Frequent small applications are better than occasional large applications.

9. Lime should be used with reference to the rotation rather than a single crop.

10. The full effect of lime is secured only when it is thoroughly distributed through the soil to the depth of rooting.

Lime does not leach out of the soil rapidly. Therefore, where the subsoil, as well as the soil, is acid it is advisable to plow under lime. Remember that the next plowing will return some of it to the surface. In a rotation it is a good plan to apply lime, not just ahead of the particular crop to be benefited but ahead of one, two, or more crops for which the land is thoroughly tilled so that it will be thoroughly incorporated.

The time of year when lime is applied is agriculturally of small concern. Convenience should be the keynote. It is a good rule to put it on whenever time and field conditions permit; to secure and perhaps apply it in winter and summer when the general demand for the material is light is a help to the manufacturer without being a disadvantage to the farmer.

The use of lime at the time of seeding is generally not advisable. It is best applied with a lime distributor. Fertilizer distributors generally do not have sufficient capacity unless the land is gone over 2 or 3 times, and some forms such as hydrated, do not feed in the ordinary fertilizer attachment.

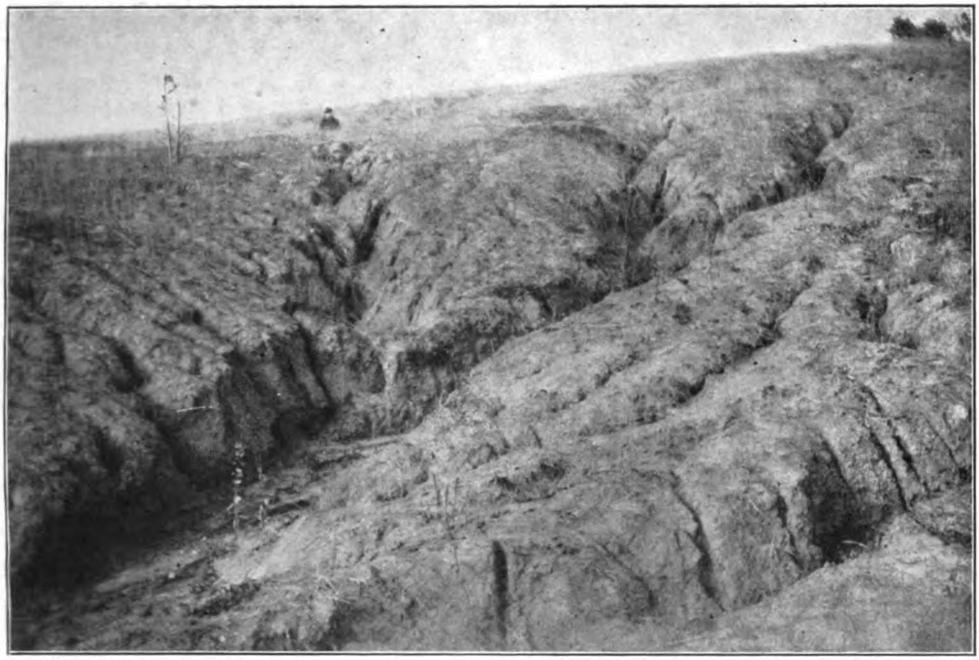
Commercial Fertilizers

The primary function of commercial fertilizers is to supply one or more of the following plant nutrients in available form: nitrogen, phosphorus, potassium, and to a less extent sulphur. Of the 10 elements required by plants as nutrients as listed on page 23, the first 3—carbon, oxygen, and hydrogen—make up 90 per cent or more of the dry weight of plants, but they are never used as fertilizers because natural processes supply them. Iron is used in such small amounts, and is present in all soils in such large amounts, that its use as a fertilizer has seldom seemed necessary. Finally, if calcium and magnesium—the lime bases—are present in sufficient quantity to keep the soil nearly neutral, they need not be added for nutrient purposes, that is, as commercial fertilizers.

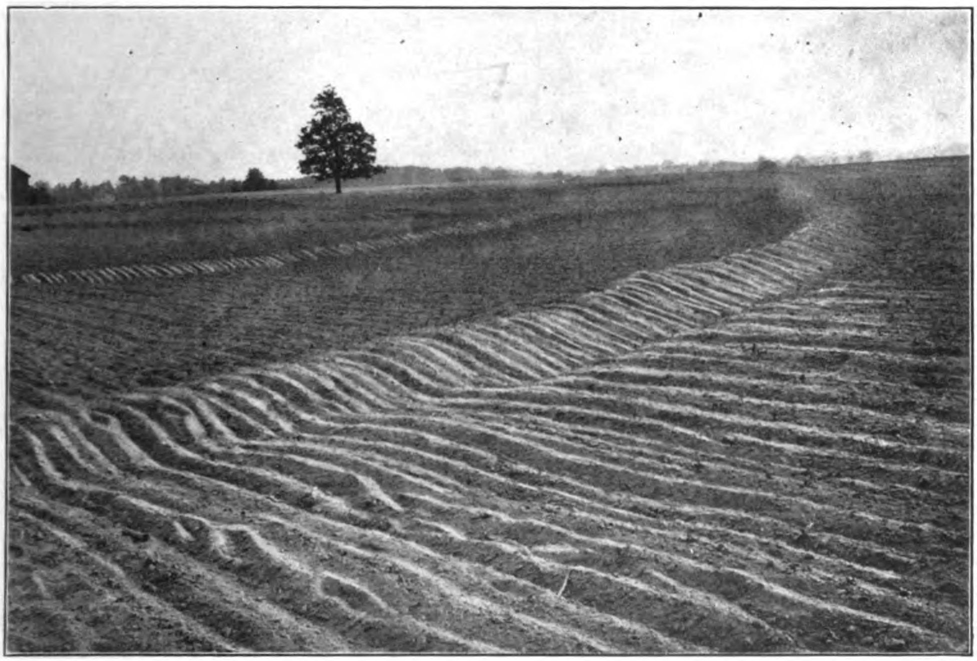
The choice of a fertilizer. The composition of crops and the amounts of these nutrients they receive per acre (see p. 26) must be taken account of as a sort of basic fact. But it is not and never has been practicable (except in the most intensive types of agriculture such as vegetable gardening and floriculture) for the farmer to use plant nutrients in the amounts in which they are taken off by crops; nor is this often necessary.

The composition of the soil must be kept in mind. It has been shown in Chapter 2 that the average or normal soil contains many times as much of all these critical plant nutrients in the surface foot as is used by a single crop. And with the exception of nitrogen they are just as abundant in the lower depths. Thus, not only the amount of those nutrients in the soil, but also their availability must be taken into account.

On the basis of total supply in the soil at any given time, nitrogen is the least abundant nutrient in the average soil. Soils very rich in organic matter are better supplied with it than soils poor in organic matter; consequently, the latter are most in need of nitrogen fertilizers. The other fertilizer ele-



Erosion such as this ruins thousands of acres each year because farmers either do not know or do not take the trouble to find out how to stop or prevent it



One way to prevent erosion is to lay out Mangum terraces across the sloping fields. (See p. 42)

IT IS PART OF THE FARMER'S TASK TO SAFEGUARD THE SOIL FROM INJURY

Listed land on the Great Plains; the rows, running crosswise of the prevailing wind, prevent drifting and catch and hold the snow and its moisture

Measured by its results, there is no more wonderful art in the world than good plowing

TILLAGE IS THE MEANS WHEREBY ALL THAT CAN BE IS TAKEN FROM THE SOIL, AND ALL THAT CAN BE IS PUT BACK

ments in the order of their importance are phosphorus, sulphur, and potassium. Of course, particular soil conditions may modify that order.

If the supply of organic matter is maintained by the use of manure or by the growth of legumes, then, too, the order must be changed and phosphorus given first rank, with nitrogen or sulphur second. Potassium is usually the least dominant element, although some crop, potatoes, for example, frequently make good use of it.

It is evident that the selection of a suitable fertilizer is no simple matter. It cannot be done by analyzing the crop nor by analyzing the soil. The soil, the crop and the system of managing the soil must all be taken into account, for the problem is one of adjustment and a delicate one at that.

The following points should be kept in mind in making the selection of a fertilizer carrier:

1. What nutrients does it contain and how available are they?
2. The relative cost of a nutrient in different materials.
3. The composition of the material in comparison with the needs of the soil and the crop.
4. The possible residual effects of the fertilizer. What materials besides the nutrients does it carry that may be either beneficial or injurious?
5. Practical convenience in procuring and handling the fertilizer. Some materials form hard lumps and must be pulverized; others are sticky; others must be treated with chemicals or steamed and ground.

Fertilizers are of two general kinds: (1) Materials that occur in the natural form in which they are used or are the direct result of industrial processes and which may be termed "fertilizer carriers." Most of these contain only one of the fertilizer constituents at least in considerable amounts. (2) Materials that result from the mixture of two or more carriers of fertilizer constituents. These are termed "mixed fertilizers" and are usually designed to meet particular needs of special soils and crops.

Fertilizer carriers. These may be grouped according to the nutrients they carry in largest amount. The following table lists the more important, giving their average composition and indicating their availability.

COMPOSITION OF THE COMMON FERTILIZER MATERIALS

	AVAILABILITY	POUNDS PER HUNDRED							
		Nitrogen	Phosphoric Acid		Potash		Calcium		Sulphur
		N	P_2O_5	P	K_2O	K	CaO	Ca	S
Nitrogen carriers									
1. Sodium nitrate	r s	15	......	.....	.....	.....	.....	.....	.....
2. Ammonium sulphate	r s	20	......	.....	.....	.....	.....	.....	22
3. Potassium nitrate	r s	13	......	.....	44	36.5	.....	.....	.....
4. Calcium cyanamid (lime nitrogen)	r s	10–16	......	.....	.....	.....	40	28	.....
5. Calcium nitrate	r s	12–14	......	.....	.....	.....	52	22	.....
6. Cottonseed meal	s s	7.5	2.5	1.0	1.8	1.5	.....	.....	.8
7. Dried blood (red)	r s	14	......	.....	.....	.....	.....	.....	.....
8. Dried blood (black)	r s	6–12	......	.....	.....	.....	.....	.....	.....
9. Tankage	m s	4–10	2–18	1–8	.....	.....	10–15	7–10	.....
10. Tankage (concentrated)	m s	10–12	2–4	1–1.8	.....	.....	8–12	5–8	.....
11. Fish (dried)	m s	8–10	5.5–7	2.5–3	.....	.....	7–8	5–6	.....
12. Fish (acidulated)	m s	5	3	1.3	.....	.....	4–5	3–4	1
13. Dried meat	m s	13–14	......	.....	.....	.....	.....	.....	.....
14. Hoof meal	v s s	10–15	1.5–2	.7–.9	.....	.....	.....	.....	.05
15. Garbage tankage (variable)	s s	3–5	1.5–3	.04–.6	.7–1.5	.6–1.5	.....	.....	.....
16. Dried manures	m s	1–2.5	1.5–2	.6–.7	.8–1.5	.7–1.2	.....	.....	.....
17. Nitrogenous guanos	m s	7	9	4	.....	.....	.....	.....	.....
18. Hair	v s s	14–16	......	.....	.....	.....	.....	.....	.6
19. Leather meal	v s s	7–12	......	.....	.....	.....	.....	.....	.....
20. Wool waste	v s s	5–6	2–4	.9–1.8	1–5	.8–2.5	.....	.....	.6
Phosphorus carriers									
21. Acid phosphate	r s	....	15–18	5–8	.....	.....	22–27	15–19	8
22. Basic slag phosphate	r s	....	10–18	4–8	.....	.....	42–45	29–32	.4
23. Rock phosphate	s s	....	27–36	11–16	.....	.....	38–50	27–35	.....
24. Raw bonemeal	s s	3–4	21–25	9–11	.....	.....	32	33	.....
25. Steamed bonemeal	m s	2–5	23–25	10–11	.....	.....	54	24	.....
26. Bone black (animal charcoal)	m s	....	25–35	11–15	.....	.....	45–50	25–35	.....
27. Dissolved bone black	m s	....	15–16	5–7	.....	.....	15–18	11–14	.7
Potassium carriers									
28. Muriate of potash	r s	....	......	.....	50–53	41–44	.....	.....	.....
29. Sulphate of potash	r s	....	......	.....	48–51	40–52	.....	.....	16
30. Potash manure salt	r s	....	......	.....	11	9	.....	.....	5
31. Potash double manure salt	r s	....	......	.....	22–24	26–29	.....	.....	8
32. Kainit	r s	....	......	.....	12–13	10–11	.....	.....	12
33. Carnallite	r s	....	......	.....	13–14	10–11	.....	.....	3
34. Wood ashes	m s	....	......	..4–9	4–9	3–6	25–40	17–25	.....

Key: r s—readily soluble; m s—moderately soluble; s s—slowly soluble; v s s—very slowly soluble.

Home-mixed fertilizers. When a farmer has learned from experience that one or more plant nutrients produce profitable increases in yield on his land, he may purchase the carriers of those nutrients, mix them together and apply to the soil. This practice requires information as to the composition, character, and cost of those materials; ability to calculate the proportions to get the desired composition; and some labor in making the mixture. Possibly the cost may be increased by purchasing the carriers in small lots. If these and other difficulties are overcome, the farmer may expect good results from these home-mixed fertilizers if wisely combined.

Commercial mixed fertilizers. The selection and mixing of suitable fertilizer carriers for each crop and soil is the last rather than the first step taken by the average farmer. The fertilizer manufacturer has builded his business upon his special knowledge of these carriers and of the average response of crops and soils to particular combinations; upon the necessity of collecting carriers from different sources and often preparing, treating, and grinding them, all of which involves special and expensive machinery; and upon the fact that the materials must be stored and distributed to farmers and credit extended.

This phase of the business of fertilizer manufacture is a thoroughly legitimate one and a great convenience to farmers. Part of this trade practice has been the development of special mixtures designated for special crops or special soils and bearing a brand, or trade-mark, named. For example, there may be Horseshoe brand of Truck Special, carrying 3 per cent of nitrogen, 8 per cent of phosphoric acid, and 4 per cent of potash. Unfortunately, fertilizers have been very largely purchased on the basis of trade names rather than with understanding of their composition. There may be several brands of fertilizer all having approximately the same composition of plant nutrients, which may be made from the same materials, or from different sources not of equal value for all soils and crops.

The government inspection of fertilizers. The fact that fertilizers have been largely pushed out to the farmer by the manufacturer, rather than reached for by the farmer, has given the manufacturer the advantage in the transaction. The value of fertilizer in any case lies in its chemical composition rather than in any gross appearance it may present. As a result a few unscrupulous manufacturers and dealers have taken advantage of their confidential position to sell fertilizer materials that were fraudulent in composition or character.

To protect the farmer, as well as the honest manufacturers and dealers, the governments of most states have found it necessary to supervise the business of fertilizer distribution. They require that each brand of fertilizer offered for sale in each state must be licensed at some central office and a guarantee given of its composition. The government office checks up these guarantees by collecting samples of any materials found in the trade, and analyzing them. If there is an appreciable deficiency the manufacturer is liable to prosecution. As a matter of fact the superior force of this guarantee lies in the undesirable publicity that is given to any manufacturer whose product constantly falls below his guarantee, through a bulletin published annually. This gives the names of all manufacturers, the names of the brands of fertilizer they are licensed to sell, their guaranteed analyses, and the analyses of inspected samples. Any farmer can secure this bulletin each year from the proper office (either his state agricultural experiment station or his state department of agriculture) without cost. With this source of information there should be no excuse for any farmer purchasing any fertilizer, whether natural carrier, or manufactured article without being reasonably certain of its composition.

The one point about which the farmer may be in doubt in purchasing mixed fertilizer is the form of the carrier of the nutrient. He is not able to know whether the nitrogen is derived from nitrate of soda, which is readily soluble, or from bone, hair, or some other very unavailable carrier. Most manufacturers introduce nitrogen in more than one form to provide for different requirements of the crop. But some of the nitrogen carriers, such as hair and horn and hoof meal, that are naturally very unavailable, may be rendered much less so by processes known to the manufacturers so that the presence of such materials in a mixed fertilizer is not necessarily objectionable. If the guaranteed analysis shows that the essential elements are present in soluble or available form, the material may safely be purchased. This applies especially to phosphoric acid and potash; in the case of nitrogen it is difficult to give a guarantee of availability unless the carriers are designated.

Practical rules for fertilizer selection and use. The big, practical question in the mind of nearly every farmer is what material to use on his soil and crop. While it can be finally answered only by field trials and experiments, we may lay down some general rules for the use of fertilizers:

1. The fertilizer that is most sure to increase the crop yield is a complete one containing nitrogen, phosphorus, sulphur, and potassium. It does not necessarily follow that such a fertilizer is the most profitable one to use.

2. On light-colored soils showing a lack of organic matter, nitrogen is the most important nutrient.

3. On dark-colored soils containing a good supply of organic matter, nitrogen is usually

not needed except for very intensive practice such as vegetable growing.

4. Nitrogen is especially needed by crops started in late fall and in early spring. In the former case it stimulates the root growth so that crops better withstand heaving; in the latter, it is supplied at a time when the nitrogen in the soil is least available.

5. Vegetable and foliage crops have a greater need of nitrogen than seed crops.

6. The nitrogen is better secured from two or more sources than from one source. For quick effects nitrate of soda, sulphate of ammonia and dried blood or similar materials should be used. For slower effects the organic carriers of nitrogen such as tankage, bone, and treated hair, are suitable.

7. Nitrogen fertilizers are less needed on leguminous crops than on non-legumes.

8. Nearly all soils will respond to the use of soluble phosphoric acid.

9. Seed crops have an especial need for phosphorus fertilizers.

10. Acid phosphate, Thomas phosphate powder or basic slag, and fine-ground bone meal are effective on more soils than any other carrier of phosphorus. Less available carriers, such as raw rock phosphate, should be used cautiously until their value on the soil involved has been proved by experiment.

11. Potash is of uncertain value. The inclusion of 4 to 8 per cent will frequently increase the yield. Very siliceous (sandy) soils and muck and peat soils are most likely to respond to its use.

12. Potassium is especially useful for root and tuber crops.

13. Sulphur is supplied as an incidental element in acid phosphate, in sulphate of potash and in sulphate of ammonia.

14. In purchasing mixed fertilizers, high-grade materials are more economical per pound of plant nutrient than low-grade materials. By high grade is meant a material that carries the higher amounts of the fertilizer nutrients. The limit is reached when the material is made up entirely of the standard, high-grade carriers of each nutrient. For example, a 1-6-4-fertilizer is a low-grade fertilizer; a 3-10-6 is a high-grade fertilizer. The first figure is the per cent of ammonia or nitrogen, the second is the per cent of phosphoric acid, and the third is the per cent of potash.

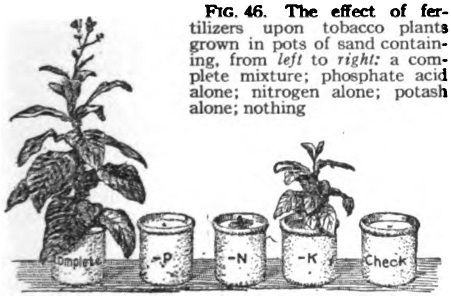


FIG. 46. The effect of fertilizers upon tobacco plants grown in pots of sand containing, from *left* to *right:* a complete mixture; phosphate acid alone; nitrogen alone; potash alone; nothing

15. The amount of fertilizer that is profitable to use depends on the value of the crop and the response of the soil. The higher the acre value of a crop the larger the amount of fertilizer that may be profitably used. A rough, general rule is to use fertilizer in value equal to from 5 to 10 per cent of a fair acre value of the crop. This means that on wheat yielding normally 20 bushels and worth a dollar a bushel, one may safely use fertilizer to the extent of from $1 to $2 per acre; on potatoes yielding 200 bushels worth $100 per acre, one may use $5 to $10 worth of fertilizer; on vegetable crops worth $300 per acre or more, one may use from $15 to $30 worth of fertilizer per acre. Of course, the response of the soil must be taken into account; the larger it is the more fertilizer one may safely use. In all cases the largest return per dollar invested is secured from small applications. The largest net return per acre is secured from a larger application that must be determined in the manner outlined above.

16. Small applications of fertilizer—up to 500 pounds per acre—may very well be placed in the row or hill. Larger applications should be thoroughly mixed with a considerable depth of soil over the entire area. If applied broadcast on the surface, it should be thoroughly worked in; if applied deeply through all the hoes of a drill, additional tillage is less necessary but may be helpful in distributing the material.

17. Very soluble fertilizers, especially those carrying nitrogen, such as nitrate of soda and sulphate of ammonia, should not be applied very long in advance of seeding or planting if much loss is to be avoided.

18. The very best results from the use of fertilizer are secured by making moderate applications 2 or 3 times during the growth of the crop (called "side dressings") in addition to the application made at planting time. In the case of cultivated crops they should be lightly worked into the soil.

19. For application on the surface, as in topdressing grass, nitrate of soda is most effective.

20. Heavy applications of fertilizer should not be mixed with the seed. Smaller ones—of 200 or 300 pounds per acre—distributed with a drill may safely be dropped with the seed.

21. The residue of a fertilizer must be taken into account. When it is objectionable, like the sulphuric acid from sulphate of ammonia which makes soil acid, it must be corrected by the use of material of the opposite chemical nature—in this case lime.

22. Fertilizers are less effective in dry than in wet years.

23. Lime should not be mixed with fertil-

izer. If applied and mixed with the soil separately, even though they immediately succeed each other, very little if any injury results.

24. Every farmer must experiment with his own soil and cropping system to determine exactly what is the most profitable amount, as well as the best kind of material, to use on the land. Every farm should be something of a soil experiment station where trials of these materials are made.

The Reclamation of Alkali Land

The excess of soluble salts in the soil which brings about the condition known as alkali can be effectively and permanently dealt with in only one way, namely by removing it. However, means that may be used to prevent the accumulation of alkali, and in some instances to temporarily neutralize its effect, may be briefly summarized as follows:

1. The prevention of evaporation reduces the accumulation of alkali in the surface soil where it is brought by the water either by gravitation or by capillary attraction. This may be accomplished by:

(a) Thorough surface tillage and mulching. In cultivated fields where irrigation water is applied in furrows, a mulch 6 to 8 inches deep has been found most effective. Coupled with this is the advantage to be secured by irrigating in deep furrows which reduces the extent to which the surface soil is wetted. Where the mulch is 6 inches deep, furrows should be 8 to 12 inches deep.

(b) Avoiding over irrigation, by which a surplus of water is accumulated in the subsoil and caused to rise toward the surface causing evaporation.

(c) Applying large rather than small amounts of water at a single irrigation. When enough water is applied to saturate the soil section 6 or 8 feet deep without seepage, the interval before another application may be long, a mulch more continuously maintained, and the proportion of evaporated water is reduced. In this way the rise of alkali is reduced.

(d) Shading the surface by keeping it covered by vegetation as far as possible; this operates like a mulch.

2. Where the bulk of the alkali salt is the sodium carbonate or black alkali, applications of gypsum are temporarily effective in changing the black alkali to other salts of the white alkali group, which is only about one-fourth as injurious as the former. One tenth of 1 per cent of black alkali—a fair limit of tolerance—amounting to a ton per acre 6 inches deep, requires at least that quantity of gypsum per acre 6 inches to neutralize it. Strongly impregnated soils require correspondingly more, which makes the expense high without giving permanent correction.

3. Growth of alkali-resisting crops may be practised in the early stages of accumulation. Saltbush, old alfalfa, sorghum, hairy vetch, radishes, sugar beets, sunflower, modiola, artichokes, carrots, and gluten wheat, are most resistant in the order named to total alkali, according to the results of the California investigations. Among fruits the date palm, grape, olive, almond, fig, orange, and pear are the most resistant in the order named.

4. Removal of the alkali salt may be accomplished by:

(a) Scraping the surface and thereby bodily removing the crust that forms.

(b) Flushing the surface. A heavy application of irrigation water is made, let stand on the soil for a time, then drawn off with the dissolved salt. However, the water that sinks into the soil carries a large amount of alkali with it, which is *not* removed from the soil and quickly returns to the surface by subsequent evaporation.

(c) Heavy flooding, which may be practised where the soil is underlaid by a porous strata of well-drained soil. The irrigation water dissolves the salt, passes down through the soil and drains away through the porous layer. So long as this process continues the benefit is thorough. But the conditions where it can be applied are very few and by not regulating the removal of the water one may be inviting future trouble.

Reclamation by drainage. The effective and permanent reclamation of alkali land and the protection of land inclined to accumulate alkali, can only be accomplished by thorough underdrainage, coupled with heavy irrigation. When the general movement of water is downward into the soil by percolation rather than upward by evaporation the alkali salt is carried away. The drainage permits this permanent downward movement by providing an outlet and suitable channels.

Drainage of irrigated and alkali land presents problems not commonly involved in the drainage of soils in humid regions. It is more necessary to study the soil structure and the course of movement of the water. Land naturally alkali is often the result of springs and subterranean seepage, sometimes from great depths. Such sources of water must be tapped and removed. As a general rule, drains in irrigated regions are placed deeper (from 4 to 6 or 7 feet) than is advisable in humid regions, partly to reduce the rate of evaporation at the surface by which alkali is brought up.

Relief wells. In addition to placing the drains deep, it has frequently been found advisable to apply the principle of relief wells advocated by Joseph Elkington in England in the latter half of the eighteenth century and for the introduction of which he received a special grant from Parliament. In this practice wells or pits are sunk below the level of the ditch to the water-bearing

layer, which may be many feet down. The water rises through these wells to the drain lines and is then easily removed. Sometimes as many as 5 or 6 wells per 100 feet of drain are advised. They are kept open by boxes or tile set on end.

Management of "quicksand" soil. This loose, wet type of soil causes trouble by forming an insecure foundation for drain pipes and slipping into the drain at every joint until it clogs it. Under such conditions every precaution must be taken: The tile should be laid on boards and the ends closely fitted; box drains may be used; silt wells at intervals should be employed. These are pits on the line of the drain sunk 3 or 4 feet below the grade of the drain and reaching to the surface. They may be walled up or made of concrete or large tile set on end. The sediment settles into these pits from which it may be removed from time to time. A small cable may be placed in each line of drain by means of which a brush or block can be drawn through it from time to time to stir up the sediment so that it can be washed out. In very bad cases it is necessary to dig below the line of the drain and fill in with fine gravel on which and in which the drain is laid and which acts as a filter, keeping out sediment.

It has been thoroughly demonstrated in many sections that the most alkali-impregnated soil—land having a heavy crust and absolutely barren of vegetation—can be reclaimed by drainage, coupled with heavy irrigation so that in 2, 3, or 4 years even the most alkali-sensitive crops can be grown. These paragraphs give only the barest outlines of the means that may be used to protect and reclaim alkali land. The general principles of drainage discussed above and in Vol. III must be applied with modifications to meet the special conditions.

FIG. 47. Knowing what our soils are, what is the matter with them in any particular case, and how we can improve them, is only a part of the battle. There remains the problem of how to handle them so as to maintain their strength and fertility. One of the means to this end is proper tillage (See next Chapter).

CHAPTER 4

Tillage and Its Relation to Soil Management

By PROFESSOR ELMER O. FIPPIN (*See Chapter 1*). *Tillage is not merely a step in the raising of crops; it is a very important feature of soil management and has a very direct effect upon both the maintenance of a soil in a good condition, and its improvement from a poor state. A man may be an excellent plowman, he may be able to handle any sort of cultural tool skilfully and well, he may be an excellent judge of plows and harrows from the structural side; but until he thoroughly understands the effect of each kind of tillage upon his particular type of soil, and is reasonably certain as to which is best for his conditions, he is but half prepared to carry on a successful tillage and therefore a successful farming campaign.*—EDITOR.

TILLAGE is the art of manipulating or handling the soil by means of various implements. The soil is thus stirred, turned over, loosened up, pulverized, leveled and compacted. Rubbish and weeds are disposed of and seeds are deposited. There is an old English saying that "Tillage is manure." Though that saying may not be true in the sense in which it was originally used, it does have a large element of truth. Formerly it was believed that the roots of plants took up the soil particles bodily and that the latter had to be fine so that they could be taken up. Now the effect of tillage is known to be largely on the physical properties of the soil by which the moisture relations and the ventilation are altered. On the chemical nature of the soil, and upon the microscopic plants and animals that live in it.

It is evident that a discussion of tillage must be guided by the functions or operations to be performed and that the various implements must be selected to do the particular work in hand. There is no best implement for all conditions. Some implements have a wider range of use than others. All must be judged along 2 lines: (1) their adaptation to modify the soil in the desired manner; and (2) their mechanical principles for ease of operation and durability. The first set of considerations is essentially agricultural, at least in their effect, and are dealt with here. The second set of considerations have to do essentially with the problems in engineering, and they are dealt with elsewhere (Chapter 7, Vol. III).

The functions of tillage may be divided into 6 groups, namely: (1) to loosen the soil; (2) to compact it; (3) to level or form its surface; (4) to cover rubbish and incorporate materials into it; (5) to destroy weeds; (6) to deposit seed.

Types of tillage implements. Tillage implements are of 4 main types. These are plows, harrows or drags, cultivators, and rollers and crushers. The plow is adapted to deep work, to moving and inverting the soil, and to covering rubbish, stubble, and manure. It is the basic tillage implement. Harrows supplement the plow in the preparation of land and are adapted to much more shallow operation. They may be used either alone on open, easily worked soils or in connection with the plow on harder soils. Cultivators are closely related to harrows in their mode of operation and use. While used to fit the soil for a crop they are more used among growing crops to stir the soil, create a mulch and destroy weeds. Rollers and clod crushers are used to pack and level the soil and to pulverize coarse lumps.

Plows and Plowing

The plow is the tool everywhere used for deep, vigorous turning and stirring of the soil. For the power required, it is the most efficient of all tillage implements. It has undergone a long and intricate process of evolution from the crooked stick used by the ancient farmer. In fact, the development of the present-day plow is very recent and has practically all been accomplished in the last century and a half. In many parts of the world the crooked stick or a close representation of it in the wooden plow is still in use.

Essential parts of a plow. The plow as it is drawn forward takes up a ribbon of soil, lifts and more or less inverts it with a twisting motion. This is accomplished by the 3 wedges of which it is composed and of which 2 have flat surfaces. These are the bottom of the plow and the landside. The third wedge has a curved surface which twists the ribbon of soil or furrow so that it is partially or wholly inverted. This is made up of the moldboard and of the cutting edge attached to it, the share.

The critical thing about the plow is the angle these various wedge faces bear to each other. Do they lift and turn the furrow acutely, or at a flat angle? Does the moldboard have a short, complete twist or a long, partial twist? Is the furrow cut entirely free from the soil below or only partially severed so that it must be broken in turning? Are the friction surfaces of such quality and shape that they polish (scour) readily, wear well and do not clog with soil? Are the parts subject to heaviest wear easily replaceable? How are the weight and thrusts of the plow borne? Do they unduly pack the soil? How are all these things related to the draft and handling of the plow?

Action of the plow on the soil. As the plow advances through the soil the furrow that is taken up is cut free from both the land and from the bottom, and slides up the curved moldboard, which twists the furrow, resulting in very complete fracture of the soil and, therefore, in pulverization (powdering). The soil inclines to be divided into a series of layers in both the horizontal and the vertical directions that slide over each other like the leaves of a book when they are bent. This is an imperfect example because the curvature is not the same in different parts of the moldboard and consequently the pulverizing action is not the same at different positions on the plow surface. At any rate, if the soil is in proper moisture condition for tillage—that mellow, moist condition when the soil breaks freely but shows no shining surfaces where it slides on the metal—it is thoroughly broken into fine crumbs that fall from the moldboard in a loose, mellow mass. If the ground is in sod the soil is pulverized just the same but the crumbs or granules are held together by the rootlets and the furrow to some extent retains its form. If the soil is too wet it puddles; if too dry, it breaks up in large lumps.

Again using the example of the leaves of a book, it may be seen that the deeper the furrow is turned, just as the larger the number of leaves bent, the greater is the sliding of the soil granules. That is to say, deep plowing pulverizes the soil more than shallow plowing. In the same way a wide furrow is pulverized more than a narrow one. Consequently the efficiency of plowing—other things being equal—is in favor of deep, wide furrows, that is, large plows.

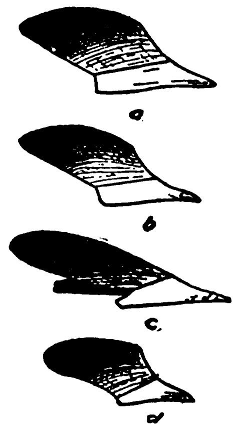


FIG. 48. Types of shares and mold boards for: *a* fallow ground, light soil; *b* fallow ground, clay soil; *c* sod land; *d* general purpose.

Types of plows in relation to the soil. Different soil conditions require different types of plows, the difference being in the shape of the cutting and twisting surfaces —the share and the moldboard. For sandy and rather dry soil a short point and a rapid rise on the share, together with a short and rather abrupt twist to the mold board are desirable. On clay soil, also a little dry, much the same form is required, but with a longer and more slender point and a little flatter rise on the share. Both these forms give the vigorous pulverization that is desired, with the minimum of draft.

On the other hand, on land bearing a heavy sod, a still longer point and a longer and more gradual turn of the moldboard are required. This form cuts the roots cleanly as they are drawn taut by the advanced point and the easy turn of the moldboard lays the furrow over in a continuous line without breaking it.

The exact type of plow that is best for each soil cannot always be predicted in advance because of peculiarities not fully understood. It must be found by trial. In the dark, red limestone soils of Cuba, for example, the modern moldboard plows have not been made to work successfully. They refuse to scour and fill up with earth so that they act merely as cultivators and do not invert the soil but only stir it.

If a soil is plowed when too wet it is puddled by the same action that would otherwise pulverize it, and dries down into a bricklike mass. If plowing at just that time is necessary, the later fitting should be done as soon as the soil had dried down to the point where puddling will not occur and before thorough drying had occurred.

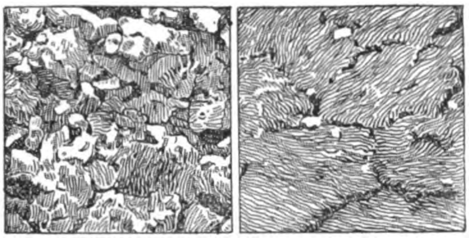


FIG. 49. A clay soil, lacking humus, becomes cloddy when tilled (*left*); it puddles and bakes after exposure during the winter (*right*). (Cornell Reading Course).

Depth of plowing. The depth of plowing cannot be stated exactly for all soils and all crops. Light and open soils that do not need to be loosened are better plowed very shallow unless some other factor, such as the working in of organic matter, enters into the case. Any compact soil, such as clay, needs to be plowed as deeply as possible to get the benefit of being loosened up and better ventilated. Well-drained soils can safely be plowed deeper than poorly-drained soils. (These statements all apply to bare land).

Most crops including corn, potatoes, beans and many vegetables, prefer a mellow but rather compact seedbed. For these, deep plowing is best. Wheat and oats on the other hand do best on a very compact seedbed; plowing, especially deep plowing shortly before seeding, frequently reduces their yield.

Still another consideration is the use of organic matter and the general maintenance of the productive capacity of the soil. As a general principle, it is advised that organic matter—manure, stubble, sod, weeds, and green manure crops—be plowed under relatively deep. Since the use of these materials should be practised on most farms, this is the same as recommending that deep plowing be practised under nearly all conditions.

What is deep plowing? It is common practice to plow from 4 to 6 inches deep but this may be considered shallow plowing. Six to 8 inches is a medium depth and anything more than 8 inches is deep plowing. The limit for depth of plowing is indefinite and determined largely by the power available, the cost of the operation and the supply of organic matter. If these are adequate the plowing may be several feet deep. In fact on sugar-cane plantations in Hawaii the land is plowed from 2 to 3 feet deep.

However, some limitations to deep plowing should be stated. (1) Most subsoils are relatively barren. That is, they will not at once grow crops if exposed at the surface. They must be weathered and incorporated with organic matter. Therefore, if the plowing of any upland soil has been shallow, the operation of deeper plowing should be practised gradually by increasing the depth only an inch or so in any one season.

(2) The subsoil is generally lacking in organic matter. A balance must, therefore, be maintained between the depth plowed and the amount of organic matter turned under. As the supply of organic matter is increased, the depth of plowing may be increased.

(3) The depth of plowing must be adjusted to the width of the furrow. Usually the furrow slice should not be turned over flat but should be set somewhat on edge. It should rest at an angle of 30 to 40 degrees with the surface of the land. By this arrangement the organic matter is better distributed through the soil and there is a good layer of free soil at the surface to be formed into a seedbed; moisture can move into the soil along the face of the furrows and return upward through the edge of the furrow; and roots can penetrate more easily than where the soil is completely inverted. To secure this right position of the furrow it should be approximately twice as wide as deep. If too narrow the furrow will be set too steep; if too wide it will set too flat. A furrow 10 inches deep should be 16 to 20 inches wide. To increase the width of the furrow in proportion to its depth requires increase in size of the plow and of the draft power. The campaign in favor of deeper plowing needs, therefore, to be supplemented by another, namely, for larger power units to draw the plows.

Draft of the plow. The draft of the moldboard plow has been found to vary as follows: (1) The draft per square inch cross-section of furrow cut *increases* as the width increases. (2) The draft per square inch cross-section of the furrow cut *decreases* as the depth increases. (3) The sharper the curve of the moldboard, the greater the draft of the plow. (4) When the soil is either too wet or too dry, the draft is increased.

The draft of the plow is ordinarily 5 to 9 pounds per square inch of cross-section for the sharp-curved or fallow-ground plow and from 4 to 8 pounds for the long-curved or sod plow. For a furrow 6 inches deep and 14 inches wide, this would be about 600 pounds in the first case and 500 in the second. For a furrow 9 inches deep and 16 inches wide, it would be about 700 and 900 pounds respectively.

The plow sole. Where soil is continually plowed to the same depth, the weight of the plow and the tramping of the team and driver pack the soil just below the furrow line so that it becomes somewhat of a hardpan, called a plow sole. This should be avoided by varying the depth of plowing from year to year. A method of deep plowing by which the formation of a plow sole is avoided, and organic matter turned under is kept fairly near the surface, consists of plowing shallow to moderately deep when the sod or manure is being turned over, say for corn. At the next plowing the soil is turned as deeply as practicable. Instead of leaving the organic matter on the surface or deep in the soil, this

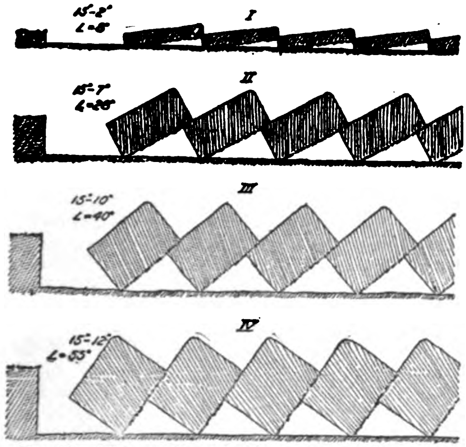


FIG. 50. The relation of width to height of furrow has an important bearing on the effectiveness of modern plowing. Of those illustrated II and III are the most satisfactory for average conditions.

brings it back fairly near the surface where it continues to be rather rapidly available.

Wheeled plows. The wheel plows of the sulky type may be used in preference to walking plows. The single sulky plow is very unsatisfactory on rolling ground because of its weight and because if one travels across the slope the furrow is not easily turned up the hill on one-half of the bout. This difficulty, and the disadvantage of the dead-furrow are both eliminated by the use of the double sulky or two-way plow. This implement carries 2 plows, one a right-hand and the other a left-hand plow, with which it is possible to plow continuously on one side of the land. The furrow can thus be always turned down the hill; dead-furrows are avoided and the surface is kept smooth.

The side-hill plow is an earlier model than the double-sulky plow, designed to avoid the necessity of traveling around the land. The mold-board is attached by a hinge joint and can be turned from side to side so that one may continually plow on one side of the land. This construction is cumbersome and built on poor mechanical lines for pulverizing the soil. The moldboard cannot be given the proper curvature.

Bad practice in plowing. In some sections of the country it is a common practice to begin at the border and plow round and round the field. The team or engine is always turned on the plowed land and packs it down hard, perhaps puddling it so that a good seedbed is difficult to form in that part. The better plan is to lay out a land with a back furrow and travel around the plowed area. Space may be left at the ends for plowing when the land becomes wide.

Disc plows. Disc plows have been introduced following the use of the disc harrow. A single disc performs all the functions of point, share and moldboard. The landside thrust is taken by a wheel since these plows must always be of the wheel or sulky type.

Disc plows are most effective on hard clay land and where much weeds, stubble and rubbish are to be turned under. They have a tremendous pulverizing action but they are not suited to sod land. The curvature is such that the sod is broken up and not properly turned. For stony and for especially hard soil, the cut-out disc is rather better than the solid disc.

Plow attachments. These play an important part in the efficient operation of the moldboard plow. Where land is in sod or bears a considerable growth of vegetation, it is hard to keep the shin sharp enough to cut it with ease. Therefore, some additional cutting edge is often advisable. The devices for this purpose are the *coulters* of various types and the *jointer*. A coulter is a blade or knife attached so as to cut the furrow free from the landside before the share and moldboard begin to turn it. A small triangular blade attached to the landside just back of the point is known as a *fin coulter*. It may be drawn out in a blade form so the tip reaches above the surface of the soil. This is one of the best types for stony soil as the stones are lifted out of the way. *Blade coulters* are attached to the beam and usually extend downward and forward. Their action is very much like that of the fin coulter but some power is saved since the entire face of the furrow is not cut free.

For land having a tall growth, especially of vines, the blade coulters are not suited because the vegetation collects on them. There and on sod land the disc or *rolling coulter* is better. It also is attached to the beam and is set to cut about an inch outside the landside so that the furrow has a sloping rather than a vertical face. This makes it easier to turn over at the next round. It is usually set down so as to cut about half the depth of the furrow but may be set deeper. This disc coulter is not well suited to stony land as even a small stone on the surface striking the coulter is likely to throw the plow out of the ground.

The jointer serves a double purpose.

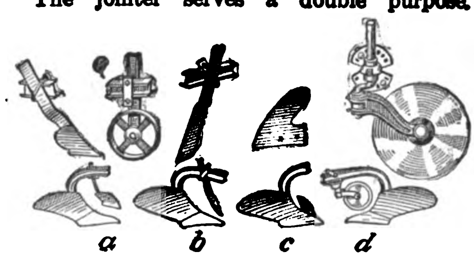


FIG. 51. Plow attachments separate and attached to show their position when in use. *a* jointer; *b* knife coulter, *c* fin coulter; *d* rolling coulter; *e* gauge wheel to regulate depth.

It is a miniature plow attached to the beam in the position of the coulter, where its sharp forward edge performs first the functions of the coulter to cut the furrow free. The curved surface then turns over the edge of the furrow so that any growth such as grass or a green-manure crop not more than a foot in height is turned under and does not stick out when the furrow is laid under. Any rubbish or stubble is also thrown over where it will fall in the bottom of the furrow. The jointer is a very handy attachment adapted to a wide range of conditions, except where there are vines. A recent development is a disc or rolling coulter with a jointer attached just back of the edge on the furrow side. By this means the advantages of the rolling coulter are combined with those of the jointer.

The position of the coulter or jointer with reference to the plow point is important. In nearly all cases it should be a short distance back of the point. The coulter should be in such position that the knife edge meets the roots in soil after it has been raised and the roots somewhat stretched by the advance of the point. This makes the cutting easier.

On muck soil first plowed and on rooty land the coulter is sometimes slanted backward instead of forward and extends from the beam to a position considerably back of the point. Thus roots are better gripped and may be cut. At the same time the plow is better held in the ground by the point.

Subsoiling. The subsoil plow is not a true plow in the sense of an implement to invert the soil. Rather, it is a deep cultivator. It consists of a long, slender shin on the bottom of which is a narrow straight point. It is used in the bottom of the furrow to break up the subsoil without turning it to the surface. Its function is to loosen up a hard, compact subsoil. A recent development is the attachment of a subsoiling point to the bottom of an ordinary turning plow so that it follows in the furrow. Thus, two operations are combined.

The operation of subsoiling is of doubtful value, especially in humid regions. It is perhaps better suited to semi-arid and arid regions wherever the subsoil is too compact. In humid regions it is best practised in the fall. Subsoiling in spring is usually disastrous. If the soil is dry enough to break up it forms such a loose layer of lumps that the soil moisture conditions are likely to be unfavorable for the remainder of the season.

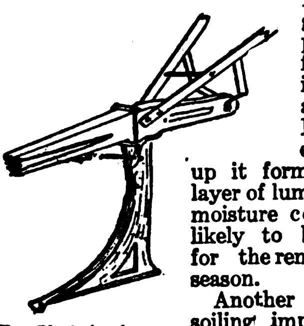


FIG. 52. A simple type of subsoil plow

Another type of subsoiling implement is the so-called deep-tillage plow. This is essentially a double disc plow, but instead of turning 2 furrows side by side the discs are set one behind the other, the second being set considerably lower so that it works on the bottom of the first furrow. Thus the subsoil is loosened up to a depth of 14 to 18 inches but instead of being turned up on the surface it is thrown up on the lower part of the preceding surface furrow, the result being a partial mixing combined with fairly deep plowing. Care must be taken in the adjustment of the discs and the depth of plowing so that the surface furrow is not covered by the subsoil material. Of course, the draft of any tool that turns two furrows, especially where one of them is the hard subsoil, is high and this has been a considerable disadvantage. At the same time it is essential to proceed with some caution to determine the conditions of soil where this tool is adopted. It is the most promising of the deep-tillage tools.

Fall or spring plowing. Whether the soil shall be plowed in spring or in fall is a question not easy to answer. The development of practice is in the direction of more fall plowing in all northern districts where the winter is severe and the spring inclined to be late. This is due to the time saved, the great labor convenience and to the beneficial effect of freezing and exposure on many soils. The frost crumbles the moist soil into a mellow condition and settles it somewhat. Small grains especially do best on such a seed-bed. Green crops and stubble turned under in the fall have a longer period to decay. It is possible to get on the soil with fitting tools earlier in the spring than would otherwise be possible. Where dry weather in late spring or summer is likely to ensue, the saving in moisture is an important factor.

Light sandy soil is usually plowed to advantage in fall but where it is exposed to heavy wind during the winter this is not advisable because it is likely to be blown away. If it is fall plowed it should be thrown up in as large ridges as possible as these break the force of the wind and largely prevent erosion.

Covering tall growth. In plowing under a large growth of crop such as green manure, it may not be possible to cover it with the plow alone. A heavy chain is commonly used to draw the top of the growth forward into the bottom of the furrow where it will be covered. The chain is usually attached to the beam near the bridle and to the outer end of the whiffletree. It is permitted to sag back to a point just ahead of where the furrow is inverted.

Harrows and Drags

In fitting a seedbed it is generally advisable to work down the soil as fast as it is plowed. At that time the lumps are moist and easily broken whereas, if permitted to dry out, they are likely to become hard. For

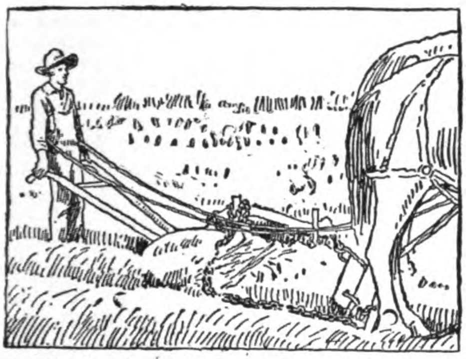


FIG. 53. A chain, attached to single tree and plowbeam, turns under high growth (Cornell Reading Course)

this reason each day's plowing should be leveled and somewhat pulverized the same day. The leading implement for this purpose is the harrow, a broad, many-toothed implement usually without wheels or guiding handles. It may be fitted with short teeth as in the spike-toothed harrow; the teeth may be on curved spring shanks as in the spring-toothed harrow and the weeder; or they may be discs that can be set at different angles as in the disc harrow. In each case their purpose is to stir, pulverize and smooth the surface.

The small-toothed harrow. The spike-toothed harrow is the least vigorous and the shallowest acting and is best suited to the more friable soils or to the later stages of fitting a lumpy soil. It is poorly suited to working up hard soil without plowing. If heavily weighted and used as a drag, it is very effective to a depth of 3 or 4 inches. On land bearing vines and weeds it is unsuited as it quickly clogs, although this difficulty is partially overcome where the slant of the teeth is adjustable. It is especially useful to break up a light crust, to lightly cover seed that has been broadcasted and to work in fertilizers and lime. It should be remembered that the best time to kill weeds is just when they have gotten well started.

The spring-toothed harrow. This has a greater range of depth and adaptability to soil conditions than the spike-toothed harrow. The length of the teeth and the angle at which they may be set enable them to reach a depth of 5 or 6 inches. They do considerable pulverizing and bring the larger lumps to the surface where they may be crushed by other means.

Closely related to the spring-toothed harrow is the weeder which has longer and lighter teeth set in a frame fitted with handles. This is more truly a cultivator and is especially suited to light cultivation on soils fairly loose and in good tilth. It is especially useful for breaking up a light crust and killing small weeds in crops just before or soon after they are through the ground. It is so wide that several ordinary rows may be covered at once which hastens the rate of covering the ground.

The disc harrow. The disc harrow stirs and pulverizes the soil and if turned at a considerable angle inverts a considerable amount of soil. For the amount of work done the draft is less than in other types of harrow. It is better suited than toothed harrows to land filled with roots, straw or other rubbish as it rolls over these and chops them up whereas other implements would clog. It will take hold of fairly hard unplowed soil and work up a seedbed. The depth of operation is regulated by the angle at which the dics are set together with the weight that may be applied.

On stony soil the cut-out disc is more effective than is the solid type. A further development of this principle is the spading disc where the cutting edges are a series of curved blades set in circular arrangement. Since the discs on one-half of the harrow all throw the soil one way and form ridges, a double type of disc has been devised in which the second set follows the first, throws the soil in the opposite direction and, being set in a different line, levels the surface. Still another development is the attachment of the two sections to the frame by means of hinges so that they are free to adjust themselves to the inequalities of the land. For orchards provision is made to move the sections to right or left so as to get up close to the trunks of trees where the limbs hang low.

The size of the discs affects the efficiency of their operation. Small discs 12 to 14 inches in diameter do the most pulverizing but the draft is high. Larger discs (16 to 20 inches) have a lighter draft, a greater range of depth and are nearly as effective.

Another type of disc harrow has small discs set rigidly on 4 straight axles one behind the other. This tool is excellent for pulverizing and packing soils that are not excessively hard and lumpy and is especially suited for fitting soil for small seeds and plants as in garden work.

Still another type deserving mention is the Acme harrow, which consists of long, twisted blades set in a ridged frame and slanted backward and slightly downward. The forward edge cuts and shaves the soil and the twist of the rear part of the blade brings about further pulverization and stirring. It is a very effective tool but has a relatively high draft for the work done.

For use on meadow and pasture land where manure has been spread in lumps and where there are droppings of animals, the Scotch chain harrow consisting of a web of rings about 4 inches in diameter is an excellent tool. These rings spread the manure and stir up the soil slightly, perhaps enough to cover grass seed.

Cultivators and Their Uses

Cultivators are used to stir the soil among growing crops, to form a mulch, to increase ventilation, and to kill weeds. Their action on the soil is the same as that of the harrow—one of stirring rather than turning. They are equipped with handles or some guiding arrangement to guide them between the rows of the crop. Their principles of construction are much the same as those of the harrow but they are more adjustable than harrows as to depth and the thoroughness with which they stir the soil. The most vital feature of a cultivator is the character of the parts by which the soil is stirred.

Small toothed cultivators. The very small-shoveled or spike-toothed cultivators are adapted to rather shallow work in rather clean and fairly mellow soil. The shovels are fashioned to draw into the soil. They are very numerous and very thoroughly stir the soil. On sandy, loamy, and silty soils they form an excellent mulch and destroy all small weeds. On hard or stony soils or around large tap-rooted weeds, this implement is of small value.

Shovel cultivators. Next in size is the cultivator having shovels 2 to 3 inches across the front face and a length of 6 to 10 inches. These are best adapted to hard, stony soil and give deep, vigorous action. Where large weeds are to be destroyed, shovels with a wider flare of the wings are desirable and if they over-lap in the soil covered, the effect is all the better. This is the most common type of shovel for general-purpose work.

In the same group is a new type of shovel having a digging face that is an even-sided triangle about 4 inches across, attached to a narrow shank. This loosens up the soil and cuts off weeds but instead of throwing the soil up in ridges the greater part of the loose earth drops over the upper edge of the shovel and falls in a fairly smooth layer that results in less evaporation than the ridged surface. The shovel is given a large forward slope so that it shaves the soil-layer free. A further extension of this principle of wing shovels is found in the sweeps or thistle cutters, much used in cultivating cotton. These shovels are short and broad, the wings spreading 10 inches or more in the extreme types. They, too, are drawn in a very flat position so as to shear off a layer of soil and let it drop back to form a very smooth surface. They are adapted to very shallow tillage and to the destruction of weeds and work admirably in all the looser soils. However, they are of little use in hard or stony soil as they are continually thrown from side to side when they meet hard obstructions.

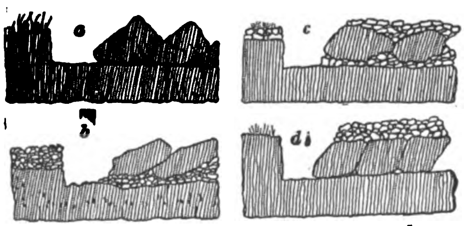


FIG. 54. Diagrams to show the effect of different steps in preparing a seedbed: *a* land plowed; *b* disked then plowed; *c* disked, plowed, then harrowed; *d* plowed, rolled, then harrowed.

Another development of the same idea is the cultivator equipped with long, flat shovels that are carried forward in the soil in a slantwise position with the surface of the shovels nearly parallel with the surface of the soil, their ends lapping. The soil easily slips over the cutting edges. For forming a very shallow surface mulch without seriously disturbing crop roots, or destroying small weeds, weeds with numerous underground stems and those which must be destroyed by preventing top growth, this type of shovel is ideal. Examples of the plants against which this implement is especially effective are quack grass, wild pea vine, milk-weed, and, in the South, Bermuda grass and Johnson grass. It is especially necessary that the soil be free from stone and not too hard, for the effective use of this type of shovel. When these wing shovels are curved in one direction or set with their face to one side, they are adapted to throwing the soil toward or away from the crop or ridging it up.

Spring-tooth and disc cultivators have special uses but are not likely to generally displace the ordinary type made up of several straight-shovel cultivators.

The entire trend in cultivators is toward those types that keep the soil relatively level. For general use the numerous small-shovel type is preferred. Whether they shall be adapted to one or two or more rows; whether they shall be carried on wheels; whether to be guided by feet or hands, etc.—these are matters for personal decision.

Depth of cultivation. The depth to which the cultivator should be run must be determined by the primary purpose for which it is used. A soil mulch—a loose, dry layer of soil—to conserve moisture should be only a couple of inches in depth and as level as possible. Deeper stirring wastes water and is likely to disturb many roots—which should always be avoided. More shallow cultivation is advisable wherever practicable.

For killing weeds the depth of cultivation must be determined very much by their size. Small weeds may often be killed by very lightly stirring the soil, while large ones require more vigorous action. The practice frequently followed of tearing up the soil with the cultivator as deeply as possible is generally bad.

Ridging vs. level culture. Ridging crops is seldom an advantage. Even such crops as potatoes are best grown under level culture if

the soil can be properly worked. If the tubers are planted 4 to 5 inches below the general surface there is very little need of a ridge in the latter part of the season to keep the tubers covered. If the soil is very wet then there may be reason for ridging the soil to hasten evaporation, but this is really only an excuse for the lack of drainage.

Plowing orchards. Plowing in established orchards should be done with caution. If the land has not previously been plowed, most of the roots are developed very near the surface and will be destroyed by deep plowing. Where it is desirable to plow as deep as 6 inches or more, this depth should be attained gradually—a little each year—so that new roots are developed below to support the tree. Surface tillage should be very shallow and the ground should be kept level.

Seeder cultivators. Most seeders that deposit the seed in rows have the same effect on the soil as a cultivator and their use amounts to one treatment with a fitting tool. The grain drill especially has this effect. Some harvesting tools such as the potato digger and the bean puller stir the soil and produce some of the same beneficial effects on the succeeding crop as thorough cultivation; this is one of the special advantages of the potato crop.

The lister is a special type of combined tillage and seeding implement. A right and left moldboard are united to throw furrows both ways. In the double furrow thus formed the seed is deposited by a suitable drill shoe. This is a pioneering implement not used where the best crop yields are expected.

Rollers, Packers, and Pulverizers

The roller is used to smooth the surface soil, pulverize lumps and compact the soil. The solid roller may be used to press the roots of crops more firmly in the soil; for example, in rolling meadows in early spring. For merely smoothing the surface the solid barrel roller is undoubtedly the best implement if sufficiently weighted. As a pulverizer and for packing the lower part of the soil, the solid roller is very inefficient.

It should be remembered that freshly plowed soil is usually too loose to make a good seedbed. There may be large voids between the furrows; therefore it must be packed and pulverized. If the soil is in the right moisture condition for tillage, it is difficult to give too much packing. A tool that concentrates its force and presses into the soil is good for these purposes, wherefore the bar roller, the corrugated roller and the so-called pulverizers have come into use. They have been called subsurface packers since they pulverize lumps, press into the lower soil and leave a loose layer of soil on the surface to serve as a mulch. They compact the lower part of the soil better than a solid roller. These tools also deserve the name of clod crushers. The roller of small diameter is more effective than one of larger size.

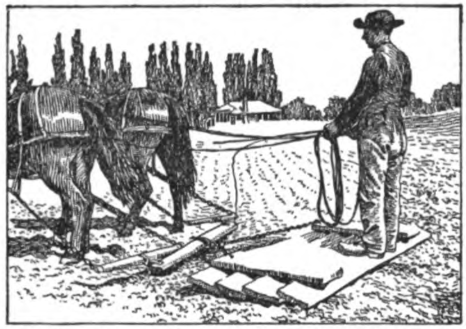


FIG. 55. The planker, an easily-made but effective soil smoother and pulverizer

The planker. As a leveling and pulverizing tool, the planker is very efficient. It consists of 3 or 4 2-inch planks fastened together so they overlap and form a ridged surface and is drawn with the overlapping edges forward in contact with the soil. It rolls and grinds the soil and at the same time does considerable leveling. If used in connection with a toothed harrow it is especially effective in reducing lumps.

Fitting the soil. In preparing sod land it is common practice to roll immediately after plowing, to press down the furrows and smooth them so that the team can travel easier; the disc harrow may be used for much the same purpose. Either tool should travel parallel with the furrows. Afterward the successive use of a harrow and a pulverizer or planker brings the lumps to the surface, pulverizes them, and packs the soil. Thorough fitting is important. The stirring and exposure to the air and sun are very beneficial in ways not fully understood, but soils so treated invariably give a larger response in crop yields than soils poorly fitted.

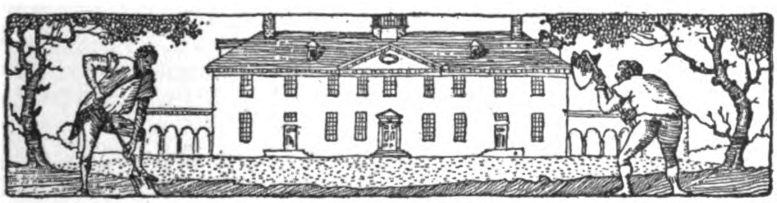


FIG. 56. The sack on the man's shoulder contains the threshed barley grown on a half acre of land continuously cropped for 4 years. The sacks on the ground contain the crop grown on the same area of similar land summer fallowed (p. 69) the year before.

CHAPTER 5

Dry-Farming

By DIRECTOR W. M. JARDINE *of the Kansas Agricultural Experiment Station, whose experiences in the semi-arid West began on the ranches of Idaho and Montana where he lived and worked for* 20 *years. After studying at the Utah Agricultural College, he joined its Agronomy Department, rising to the position of Professor in* 1906. *From* 1907 *to* 1910 *he investigated dry-land crops for the U. S. Department of Agriculture, then became Agronomist of the Kansas Agricultural College, where in* 1913, *he was made Dean and Director of the Experiment Station. Throughout his teaching and investigational work he has kept in close touch and sympathy with practical farming methods and the aims and needs of practical farmers.*—EDITOR.

WHAT it is. Dry-farming may be called the art of producing crops where the annual precipitation, that is, rain, snow, and other forms of moisture, is 20 inches or less, but its principles apply to practically all conditions under which crops are grown. Dry-farming was at first concerned with only the conservation of water, but it now includes also the best crops to grow, methods of planting, rotation of crops, the production of livestock under arid conditions, the maintenance of soil fertility, and even the problem of making the dry-farm home more attractive and a better place in which to live.

Dry-farming extends back into the earliest days of the world's history, many of the methods now employed being used by the ancients. In the United States, dry-farming, as a system, has been in use for 50 years, first being practised by the Mormons in Utah.

FIG. 57. Distribution of rainfall in 3 sections of the Far West. Each black column represents inches of rainfall in a month. The coast gets most of its rain in the winter; the Great Plains in the summer, but here evaporation is greater. (Bur. Plant Industry, Bulletin 188).

Where it is practised. About 55 per cent of the world's land surface and nearly 50 per cent of the area of the United States must be farmed by dry-farming methods. There are two well-defined dry-farming areas in the United States (Fig. 58) which differ from each other in climate, and to some extent in crops grown and methods of culture

employed. One region comprises the areas of limited rainfall west of the Rocky Mountains and includes especially the Columbia River basin in Washington and Oregon, the valleys of the Sacramento and San Joaquin rivers of California, and the Great Basin of Utah, Nevada, Idaho, and Wyoming. The second area is the Great Plains which extends from Canada nearly to the Gulf of Mexico, and from about the ninety-eighth meridian to the Rocky Mountains. As a rule, dry-farming has been less successful in the second of these areas than in the first. This may be due (1) to more hot, dry wind and greater evaporation, and (2) to the fact that dry-farming is a new art in this section and that there has been less opportunity to develop practices or to choose crops best suited to the conditions there.

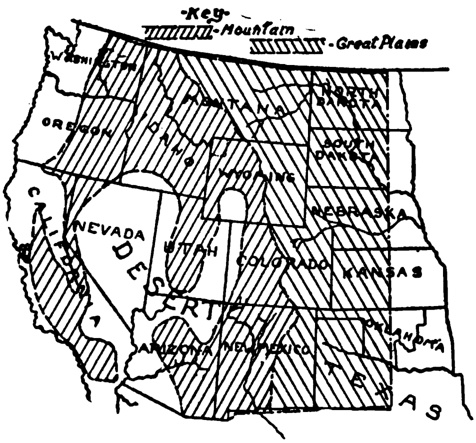


FIG. 58. The two main dry-farming sections

Water is fundamental in dry-farming; it is the limiting factor in the production of crops under this system. The primary objects are: (1) the saving of the greatest possible amount of annual rainfall; and (2) the economical utilization of water. In accomplishing these objects, work along two general lines has been necessary: first, the management of the soil to keep it in ideal condition for absorbing and retaining the maximum amount of rainfall; second, the development of crops that will produce profitable yields on the least possible amount of water.

In selecting a dry-farm in any region, the principal factors to be considered are (1) the amount and distribution of rainfall, (2) the character and depth of the soil and subsoil, (3) the length of the growing season, and (4) the rate and amount of evaporation.

Rainfall. The dry-farming area west of the Rocky Mountains is especially characterized by receiving the greater part of the total rainfall during the winter and early spring months. In the Great Plains area very little precipitation occurs during the winter, but rather during the spring and early summer.

Soil and subsoil. The farmer cannot control the amount of rainfall or the time of its coming. Therefore he must manage his soil as a reservoir in which to store the maximum amount of rainfall at whatever time it comes. A shallow soil will form a shallow reservoir; a deep soil with a good subsoil will form an effective reservoir. A shallow soil requires a greater amount of rainfall to produce crops than a deep soil. A soil should be open enough to absorb water quickly and deep enough to retain the maximum amount of water within the range of growing crops. To make this possible the right kind of subsoil is a necessity. In general the subsoil should be rather heavy but it should not prevent either rain or plant roots from making their way into it. It must be fairly loose, yet it should not allow water to percolate or leach beyond the reach of plants. Wheat has been known to root as far down as 8 feet in search of water and food under dry-farming conditions, hence the soil and subsoil should be capable of holding water to such a depth. In the Great Plains area much of the rainfall comes in heavy downpours which run off excessively and are largely wasted on a tight, heavy soil.

The ideal soil for dry-farming, considered from the point of view of the water it will hold, the fertility, and the ease with which it may be handled, is a loam, varying from a sandy to a clay loam. A clay soil is ordinarily too heavy, somewhat difficult to work, and does not absorb water rapidly enough. A sandy soil absorbs water quickly but will not retain a large percentage unless it has a heavy subsoil. However, a sandy soil will often give up 97 per cent of its water to growing plants, while a clay soil will retain as much as 20 per cent.

The length of the growing season. The length of the growing season is an important consideration with dry-farming crops such as

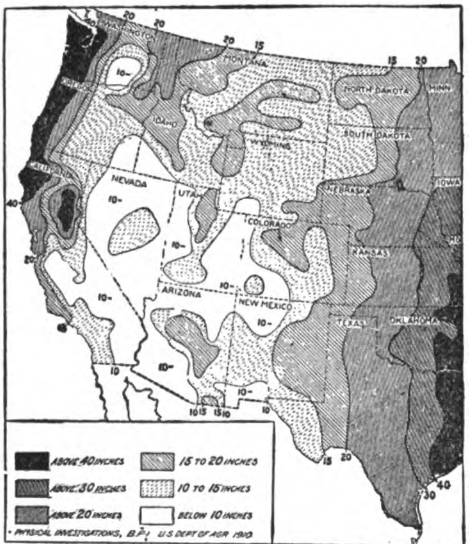


FIG. 59. The distribution of the annual rainfall over western United States (B. P. I. Bulletin 188)

the sorghums which require a long season in which to mature. In some parts of Canada and the United States, either because of the location or the elevation, the time between spring and fall frosts is too short to permit any but the earliest crops to ripen.

Evaporation. The amount of evaporation is a very important factor in determining the desirability of a section for dry-farming purposes, since whatever the total rainfall it reduces the amount that is really effective, and, therefore, the size of the crop which can be grown. For example, it has been found easier to grow a crop in western North Dakota with 16 to 17 inches of rain in a season than in the Panhandle of Texas where the annual rainfall is 22 inches. The evaporation during the growing season in western North Dakota is only about 30 inches, while in northern Texas it is more than 50 inches. The prevailing hot, dry winds in the latter area cause an excessive loss of water through evaporation, and make it difficult to grow crops even when abundant water is present in the soil.

How Soil Moisture is Lost

The two principal sources of loss of water in dry-farm soils are weeds and evaporation. If weeds are allowed to grow the loss is very great, hence it is very necessary in preparing land for a crop that weeds be kept down. Weeds use at least 250 pounds of water for each pound of dry matter produced, and soon exhaust all the surplus water present in a soil. A smooth, compact soil permits much loss of water through evaporation, therefore the surface of the soil should be kept broken by cultivation. If this is done, the movement of air in the soil is partially intercepted and the tendency of the water to rise through the soil to the surface is reduced. A certain amount of cultivation is therefore necessary to control weeds and prevent evaporation; but excessive cultivation with implements which finely pulverize the soil should be avoided, especially in areas where soil blowing occurs.

How to Manage Soils to Conserve Moisture

This problem involves two essential steps: (1) keeping the surface in such a condition that water will be absorbed readily; and (2) handling the land so that as much water as possible will be retained for the use of crops. A smooth, hard soil surface offers little obstruction to the flow of water over it, consequently most of the water runs off a field in such a condition before it can be absorbed. On the other hand, a freshly plowed field offers numerous obstructions and the looseness of the soil makes it easy for the water to reach the subsoil. Disking the ground immediately after harvest partially takes the place of plowing where plowing is not possible. Experiments at the North Platte, Nebraska, Station showed that a cultivated corn field absorbed enough water to wet the soil to a depth of 18 inches, while the same amount of rain wet the soil in an alfalfa field to a depth of only 5 inches.

Reasonably deep plowing is desirable since it produces obstructions to the flow of water and increases the water-holding capacity. However, experiments have failed to show any great advantages from extremely deep plowing. It usually does not pay to plow deeper than 8 inches on any kind of soil, and light soils should not be plowed to this depth. When plowing is done a short time before seeding, it must be shallow, otherwise the soil is likely to be too loose for a good seedbed. In general, subsoiling does not pay in dry-farming.

Value of humus. The water-holding power of a sandy soil and the water-absorbing power of a clay soil may be increased by working into them barnyard manure, corn stalks, wheat stubble, and green manuring crops such as volunteer wheat, winter rye, all kinds of legumes, and weeds plowed under when green. The addition of such materials to a soil also renders it more easily handled and increases the supply of plant food. Since a fertile soil requires less water to produce a crop than an infertile soil, the dry-farmer who increases his soil fertility is at the same time economizing the water supply.

Water That Can and Cannot be Used

The dry-farmer should remember that a soil may contain a considerable amount of water and yet have none available for the use of plants growing on it. Soils are made up of numerous, tiny, individual soil particles. These have a strong attraction for water. Through the strength of this attraction the water in a soil is held there in the form of films surrounding the soil particles. Roots of plants also have an attraction for water so that when plants are growing in a soil there are two forces attracting the moisture supply. When the films of water about the soil particles are thick, the plant roots are able to overcome the attraction of the soil particles and secure water for their needs. Water so taken by plants is the *available water* of a soil. When the films of water are reduced to thin layers, the attraction of the soil particles is greater than that of the plant roots and the water cannot be taken away by the plants. The water thus held by the soil particles is called the **non-available water.**

Table 1 lists 4 of the more common types of soil and the following facts regarding each: (a) The amount of water it will ordinarily hold expressed as a percentage of the total weight of the soil. (b) The point at which plants growing on that soil will begin to wilt, expressed as a number which merely shows the relative speed with which the different types lose their moisture. (c) The percentage of available water. (d) The number of inches of such water in the top 4 feet of soil. (e) The estimated crop of wheat that the largest possible supply of available water will produce.

TABLE 1. MOISTURE CONTENT AND PRODUCING POWERS OF SOIL TYPES

	WATER CONTENT PER CENT	APPROX. WILTING POINT	AVAILABLE WATER PER CENT	AVAILABLE WATER TO DEPTH OF 4 FEET (Inches)	BUSHELS OF WHEAT
Coarse sand	10.6	3	7.6	5.20	19.0
Fine sandy loam	18.0	5	13.0	8.50	31.5
Light silt loam	20.9	10	10.9	6.90	25.5
Clay	30.4	17	13.4	7.03	26.3

Summer Fallow

Probably the one feature of dry-farming that especially makes it differ from other kinds is the use of the summer fallow to conserve moisture. Summer fallowing consists in plowing and cultivating land for a season without growing a crop on it. Fallow land

FIG. 60. Hulless barley grown on a half acre of land after 4 years of continuous cropping. (This and Figs. 56 and 61 from Mont. Bulletin 83).

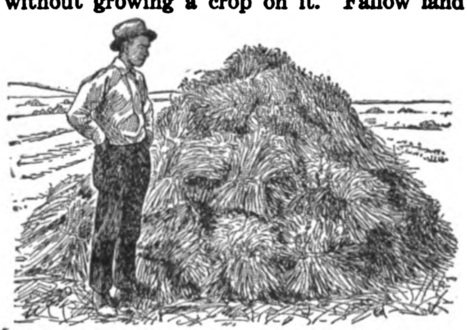


FIG. 61. Barley grown on a half acre of land summer fallowed the year before. The grain yield from both these plots is shown in Fig. 56.

kept in proper condition will absorb water readily and retain most of the moisture for the following season. The practice is most profitable where the annual precipitation is insufficient to grow a crop. It is used extensively in Utah, eastern Washington and Oregon, and other Western states where most of the moisture comes in the fall and winter; but it has not come into general use in the Great Plains although experiments indicate its value under certain conditions. At North Platte, Nebraska, an experiment with winter wheat covering 6 years, gave an average annual yield of 35.4 bushels per acre on summer fallowed land, as compared with a yield of 12.7 bushels on land of the same type continuously cropped.

The Fort Hays Experiment Station, Hays, Kansas, compared the yields of wheat grown on land plowed late in the fall, early in the fall, early in the fall and then subsoiled, listed early in the fall, and summer fallowed. The results obtained which again showed the value of fallowing, were as follows:

TABLE 2. RESULTS OF DIFFERENT METHODS OF PREPARING THE GROUND FOR WINTER WHEAT AT HAYS, KANSAS

LAND	BUSHELS OF WHEAT PER ACRE						
	1907	1908	1910	1911	1912	1913	Average
Late fall plowed	11.7	25.6	20.3	0.0	2.3	0.8	10.1
Early fall plowed	18.2	23.2	27.8	0.3	13.8	2.3	14.2
Early fall plowed and subsoiled	13.6	30.5	39.8	0.3	20.1	4.1	18.1
Early fall listed	12.4	28.1	36.7	0.6	26.6	8.4	18.8
Fallowed	11.2	32.3	42.5	2.6	29.2	10.3	21.3

Objections to summer fallow. The principal objections to summer fallow are (1) its cost; (2) its effect on the fertility of the soil, and (3) the danger of soil blowing where high winds are common, as in the Great Plains. It requires twice as much land to grow a crop on summer fallow as by continuous cropping methods, since one half of the land is fallowed for a season before a crop is grown. Because of the growth of weeds and the need of frequent cultivation, the cost of growing a crop on fallow is also somewhat higher. The total cost, however, is considerably less than twice the cost of growing a crop by continuous methods; and since the yield is often more than twice as great, the practice proves very profitable in some areas. The frequent cultivation necessary in maintaining the fallow aërates the soil and increases the activity of the soil bacteria and the production of nitrates. These bacteria live on organic matter in the soil. For this reason the continued use of summer fallow is likely to deplete the organic matter content of the soil very rapidly.

FIG. 62. Summer fallow properly cultivated, *at left;* same uncultivated, with volunteer crop, *at right.* (Mont. Circular 3).

Summer fallow is generally not profitable as a preparation for spring-sown crops. In the northern Great Plains where spring wheat is grown, corn ground produces about as good yields as fallow. Since the corn will at least pay for its cost of production, this system of cropping is there more profitable than the use of the fallow.

Partial summer fallow. In western Kansas a method called partial summer fallow is giving good results. This consists of growing corn or kafir with the rows twice the usual distance apart. The ground is cultivated in the usual manner. A 7-foot drill which will pass between the rows is used in seeding. In this way the grain can be sown before the corn crop is matured and if desired, the stalks may be left on the ground to protect the wheat during the winter. When this method is used the yield of corn is usually as good and sometimes better than when grown in the usual way. The ground is left in good condition for wheat and most of the disadvantages of the complete summer fallow are avoided.

Soil Blowing and How To Prevent It

A serious problem of dry-farming in the Great Plains is the blowing of soil. This

occurs especially on bare soil in late winter and early spring. Growing crops are frequently greatly damaged by the rapidly moving soil particles which cut off plants and in extreme cases may entirely destroy a crop. The greatest damage occurs on bare soils which have been finely pulverized by too frequent cultivation. As far as possible the soil should be worked with a corn or beet cultivator, spring-toothed harrow, or other similar implement which breaks the soil into lumps instead of pulverizing it as does the harrow or disc pulverizer.

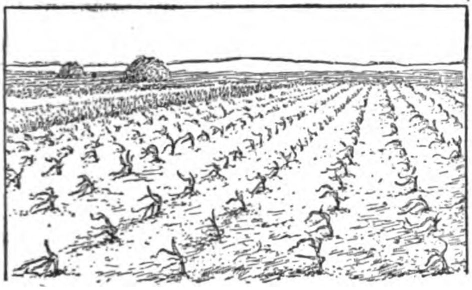


FIG. 63. Cornfield injured by blowing sand. (Farmers' Bulletin 773)

Blowing may largely be prevented by laying out the fields in long, narrow strips in which a cropped strip is alternated with one in grass or stubble during the period of the year when blowing is most likely to occur. Blowing of bare fields can be prevented by throwing the ground up in ridges as with a lister or corn cultivator, or by spreading straw and working it into the ground with a disc harrow with the discs set straight. In fields of grain, blowing can be stopped by running a corn cultivator with part of the shovels removed, through the field at right angles to the wind. This tears out some grain but the damage is small compared with the loss prevented. Another method is to run lister furrows through the field at right angles to the direction of the wind and several rods apart. The ridges break the force of the wind and cause the soil particles to lodge in the furrows. In extreme cases the furrows must be renewed from time to time until the blowing has ceased.

TABLE 3. WATER REQUIREMENT OF CROPS

KIND OF CROP	POUNDS OF WATER REQUIRED FOR EACH POUND OF DRY MATTER PRODUCED
Proso millet	293
Kafir	298
Common millet	310
Milo	328
Corn	368
Wheat	513
Barley	534
Oats	597
Potato	636
Rye	685
Sweet clover	770
Red clover	789
Alfalfa	831
Flax	905

Water Requirements of Crops

Crop plants differ remarkably in the amount of water required to produce them. Table 3 gives the number of pounds of moisture used in the production of each pound of crop including straw or stalk, leaves, and grain, when grown in the semi-arid climate of eastern Colorado and given all the water needed for normal growth.

As the table shows, the most efficient crops in the use of water are the millets and sorghums. The sorghums also have the ability to resume growth after a long-continued drought. This is a quality not possessed by other grain crops and is of considerable importance in dry areas. The sorghums, such as kafir and milo, are widely grown in the semi-arid area including western Kansas, Oklahoma, northern Texas, and eastern Colorado. They are not successful, however, in much of the dry-farm area west of the Rocky Mountains because of the cool nights. Neither are they successful at high altitudes or in areas having short growing seasons.

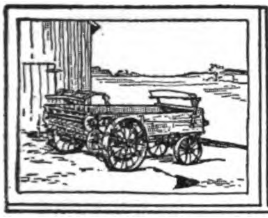
Crops for Dry-Farming

The value of a plant for dry-farming is determined largely by (1) its ability to produce a crop with a small supply of water; (2) the length of time required

for it to mature; (3) its resistance to heat and drought; and (4) its market value if grown for a cash crop or its feeding value if grown for forage. The most common and popular dry-farm crop is winter wheat, except in areas where it is unable to survive the winters. It roots deeply hence is able to secure water that is not available to many other crops; it matures early and so escapes much of the midsummer heat and drought; and it can be cheaply grown on extensive areas and marketed to better advantage than other crops suited to dry-farming. Spring wheat is next to winter wheat in importance. However, it is grown only in areas where the cold is too severe for winter wheat, as in the Dakotas and parts of Montana. Durum spring wheats are especially suited to the needs of the farmer where there is a limited rainfall.

Oats and barley are often grown where a spring-sown, small grain is desired. Of the two, barley is the most certain crop and usually produces the highest yields. However, it has a shallow root system and is sometimes less desirable than oats when water is stored in the subsoil. Flax and rye are sometimes grown on dry-farms, especially in the north half of the Great Plains area. Corn is quite extensively grown in the northern Great Plains where the seasons are too short for kafir and milo, and elsewhere when it is desired to grow wheat, because it leaves the ground in excellent condition for that cereal. Corn is very efficient in the use of water (it ranks close to the sorghums in this respect) if the yield both of grain and fodder be considered. It seldom produces paying crops of grain in dry areas, hence it is most profitably grown as feed for livestock. Potatoes produce profitable crops if the soil is not too heavy, and in addition leave the ground in excellent condition for wheat. The high cost of production prevents their more general use. Alfalfa has a high water requirement but is a valuable dry-farm crop where the water table is near the surface. The roots of alfalfa penetrate from 15 to 20 feet, hence alfalfa may obtain water at much greater depths than other crops. On dry, upland soil, alfalfa is not generally a profitable crop. Sweet clover is gaining recognition as the leading legume for dry-farming areas as a pasture crop, seed crop, and hay crop. It produces better economic results under drought conditions than alfalfa.

FIG. 64. A perfect summer fallow, properly ridged and of the right degree of fineness



FARM
KNOWLEDGE

VOLUME II—PART II

Manures, Fertilizers, and Soil Modifiers

CHAPTER 6

Farm Manures

By ALVA AGEE, *Secretary for Agriculture in the State Department of New Jersey, and formerly Director of Agricultural Extension in the Agricultural College at New Brunswick. Successful experience in building up the soil fertility of his own farm led to his appointment as a member of the Board of Control of the Ohio Experiment Station, where soil fertility is a leading project. He has been a member of the staff of the "National Stockman and Farmer" of Pittsburgh for 25 years, and as associate editor has dealt largely with soil fertility problems. He is the author of various Department and Extension bulletins, as well as "Essentials of Soil Fertility," and "Crops and Methods for Soil Improvement."*—EDITOR.

NATURE is working all the time to make and to keep soils productive. It used organic matter originally in forming the soil out of the earth's crust, and it has continued to use it, so that soils might keep their productive power. The supplies of minerals remain in a useless state unless organic matter is present. In every weed and bush and brier we see nature's endeavor to add something to the soil's supply of vegetable matter, so that better productiveness may come.

Man necessarily interrupts this process of nature, because he wants the food which vegetation provides, either directly or by means of animals. He removes the product of the soil from the land; and, if he does this in unwise degree and makes no return, the soil falls back into a helpless state. Practical men determine the productive power of a normal soil largely by the color and physical condition that indicate the percentage of organic matter in it. The appearance of a field that has been robbed of its chance to provide itself with the remains of plants is disheartening to the owner. It has lost some of the available mineral matter through removal of crops, and when it is prevented from restoring to itself the needed percentage of organic matter, it is like a cripple who has been robbed of his crutches.

Livestock farming is safest of all for the soil, because in its very nature there is some protection to the soil from robbery of the humus supply. At least some portion of the minerals used by growing plants goes back to the soil, and with it a supply of organic matter that may well be called the life of the land. Animals change its form and subtract some small percentage of its value, but the greater part remains on the farm that produced it.

What manure is. The American farmer uses the word "manure" in a re-

stricted sense. It would be correct to speak of commercial fertilizer as manure, because it contains material for soil improvement, but we confine the use of the term chiefly to that which remains from the feeding of animals, the principal exception being in the case of crops grown directly for soil improvement, and known by us as "green manures" (p. 46). In this chapter we think of farm manures solely as the excreta (feces) of animals, both solid and liquid, and the necessary amount of bedding incorporated with them.

The Composition and Value of Manure

The soil's need for organic matter to promote the freeing of inert minerals, the holding of moisture and the promotion of bacterial life, is absolute. If plants could not be plowed down to furnish humus, or did not furnish it in stubble and roots, the value of the manure from the crops removed could be measured by the value of the land, which without manure, would become worthless. Only the possibility of growing crops for soil improvement restricts the value of stable manure. But when all that is left from the feeding of a crop is returned to the land that produced it, it restores about four-fifths of the plant food removed; its fertilizing value is, therefore, on the average, four fifths that of the crop itself. The value would be greater if all were saved, because its availability is increased by its passage through the animal.

Obviously manures vary greatly in their composition, partly because of the differences in the feeding stuffs that produce them, and partly because of the different uses to which the animal may put the food. If it is a mature animal, standing idle in the stall and taking nothing from the total content of the food for increase in weight or for labor, the

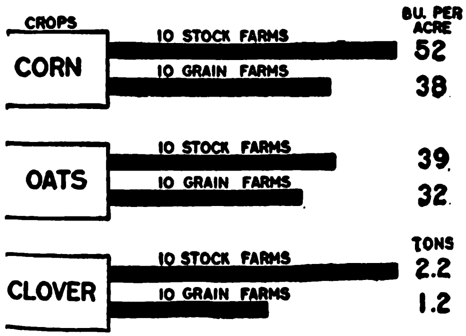


FIG. 65. One difference between stock and grain farms is a generous supply of manure. This accounts for the results charted above. (International Harvester Co.)

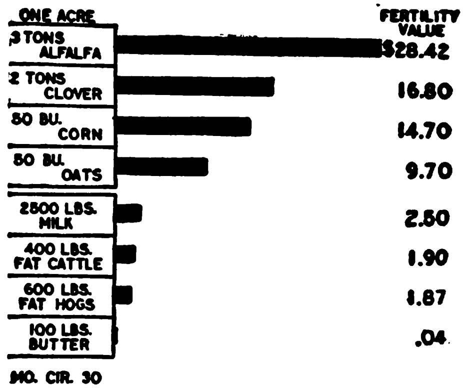


FIG. 66. Showing the value of the plant food marketed in an acre's yield of various products. The moral is, feed what you raise and return the manure to the land. (International Harvester Co.)

manure contains nearly all of the fertilizing elements originally found in the food. On the other hand, a young animal, adding continually to its bone and muscle, or a dairy cow, providing a big flow of milk rich in fertilizing elements, subtracts heavily from the supply of fertilizing elements the crop had taken out of the soil.

It must always be borne in mind that cash valuations placed upon manures are merely guides in comparison, rather than actual indications of what a farmer can afford to pay. The farm value of any manure depends upon the land and its special need, the crop that may be grown, the skill of the farmer, his market, and finally the cost of a cover crop or commercial fertilizer that might replace the manure. In practice, one man may secure a $5 increase of crop from the use of a ton of manure, while another man, differently situated, may not obtain a return of one dollar per ton, although it would be very poor farming indeed that would not make the latter return.

We cannot know the relative values of manures without some knowledge of their composition, and in comparing these values we must assume that the various kinds of animals have been fed in a normal way, receiving a reasonable amount of nutritious feeds. In these comparisons we must also assume that all of the liquid manure is saved with the solids. If this is not done, as is so often the case, the figures mean little to us, because, generally speaking, the liquid portion of the manure contains nearly half of the plant food, and the more valuable half, at that, since it is in quickly available form.

Horse manure. Accepting Van Slyke's estimates of production and value, a horse produces about 18,000 pounds of manure annually for each 1,000 pounds of live weight, to which there should be added the bedding, which has its plant food made rapidly available

FIG. 67. The twenty-seventh crop of timothy from a Missouri experimental plot that has received no treatment during the test. (Compare Fig. 69.)

by mixture with the manure. The manure (not including the bedding) contains 128 pounds of nitrogen, 43 pounds of phosphoric acid and 103 pounds of potash; and of this amount the liquid contains nearly two fifths of the nitrogen and more than two fifths of the potash. If we place a cash valuation upon this manure on the basis of prices prevailing before the European War, the value of the manure produced annually by a horse per 1,000 pounds live weight is $23.60, or $2.62 per ton. Conditions prevailing during the summer of 1917 easily doubled this valuation, which is given rather for comparison with those of other manures and commercial fertilizers than as the price any farmer should put upon his supply.

Cow manure. A dairy cow, weighing 1,000 pounds, produces one-half more weight of manure in a year than a horse, the percentage of water being much higher. The amount of nitrogen in the year's production of solid manure is practically the same as in case of the horse; that in the liquid manure is greater; and the total amount is 156 pounds. There is a little less phosphoric acid, but the potash runs up to 117 pounds, of which 108 pounds are in the liquid manure. Using the scale of prices for normal times, the valuation of the year's product is $29.60, or $2.19 per ton.

Pig manure. The pig usually is a highly fed animal, and 1,000 pounds live weight produce annually 30,500 pounds of manure, containing 150 pounds of nitrogen, 114 pounds of phosphoric acid and 128 pounds of potash, with a total valuation of $30, or $1.97 per ton.

FIG. 68. A liquid manure sprinkler is a splendid means for getting valuable plant food back into the soil

Sheep manure. The sheep per 1,000 pounds of live weight produces annually 12,500 pounds of total excrement, containing 119 pounds of nitrogen, 44 pounds of phosphoric acid and 126 pounds of potash, having a value of $24.25, or $3.88 per ton.

Hen manure. The manure from the chicken is very rich in nitrogen, averaging 1 per cent or nearly one-half more than horse manure. It also contains eight tenths of one per cent of phosphoric acid, while horse manure contains only one fourth of one per cent; and it averages four tenths of one per cent of potash. The high percentage of nitrogen and phosphoric acid gives a valuation per ton of $4.40.

Values according to field tests. These valuations, based upon the cost of plant food in

FIG. 69. The twenty seventh crop of timothy from a plot that has been manured each year during the test. More than twice as much as shown in Fig. 67.

commercial fertilizers during normal times, are consistent with the agricultural valuations of manures as determined in long-time tests at some of the leading agricultural experiment stations, when the manure was used in moderate amount throughout the rotation. The Pennsylvania Experiment Station, during a period of 30 years, found that the use of 12 tons of manure per acre during a 4-crop rotation of corn, oats, wheat and hay, made a return of $2.41 per ton, when corn was valued at 50 cents a bushel, oats at 32 cents, wheat at 80 cents, hay at $10 a ton, and oat straw, wheat straw and corn stover at $2.50 per ton. These are low valuations, and the crops are standard ones from which unusual profit is not expected. In an interesting experiment to determine the relative values of fresh and yard manure, at the Ohio Experiment Station, a record for 15 years showed that stall manure used at the rate of 8 tons per acre in a 3-year rotation of corn, wheat and clover, gave an increase in yield equal to $3.31 per ton for the manure. Its composition indicated a value of $2.50 per ton, as based upon commer-

cial fertilizer valuations. In the same experiment, yard manure, which had been subjected to some leaching, had a commercial valuation of $2.06 per ton, and gave an increased yield valued at $2.55, when used at the same rate in the same rotation.

How to Use Manures

Mixing manures. The mixing of stable manures is advisable in general farming. Horse manure is relatively dry and heating and serves as a good absorbent for the liquids in cow manure. While manure depends for its value largely upon the character of the food given, we can assume that unleached, mixed farm manures contain 10 pounds of nitrogen, 5 pounds of phosphoric acid and 10 pounds of potash per ton, and that 8 tons of manure are equivalent to 1 ton of a commercial fertilizer containing 4 per cent nitrogen, 2 per cent phosphoric acid and 4 per cent potash. They are rich in nitrogen and potash and can be made into a well-balanced fertilizer by the addition of acid phosphate, which provides the phosphorus needed by all normal soils.

Most effective uses of manure. When the supply of manure is limited, as is the case on most farms, its true function is to make heavy sods that will supply the needed organic matter during the crop rotation. When a soil is thin, a light top-dressing of manure, thoroughly worked into the surface soil, will make a big return in the catch of grass and clover. If the manure is plowed under deeply in such land, the tiny plants die before the roots can reach the manure, and the surface often is left in poor physical condition that would have been corrected by top-dressing. A light application of manure to the surface soil promotes the rooting of the small grain crop with which seeding usually is made, and the full value of the manure may be recovered in the grain crop preceding the sod. *We do not plow down the manure when the amount is small and the soil is poor.*

A profitable use of light top-dressings is upon grass lands, especially the year previous to the breaking of the sod for a tilled crop. A light dressing of new seedings to grass immediately after the harvest of a small grain is peculiarly effective, and meadows planned for breaking the following spring can be caused to produce a good fall growth for turning under if a dressing can be given immediately after the grass crop has been cut in midsummer.

On the other hand, soil fertility is quickly increased only by adding enough manure to fertilize the soil to plow depth; in well-planned and well-carried out livestock farming, there is sufficient manure to permit plowing under. In general farming, it is good practice to apply all of the manure to sod land during the summer, fall and winter previous to breaking it for corn; it will be found that the manure which goes upon the land before Christmas will bring a greater return per acre than that spread early in the spring. If the manure is plowed down in the spring for corn and oats are seeded the next spring without again breaking the ground, the plowing that follows the oat harvest for wheat brings back to the surface the remains of the manure, and provides a top soil most friendly to the wheat, grass and clover that will then be seeded. Good results come from plowing the manure down for a tilled crop, and having the reseeding to grass come after the second plowing that brings some of the manure back to the surface.

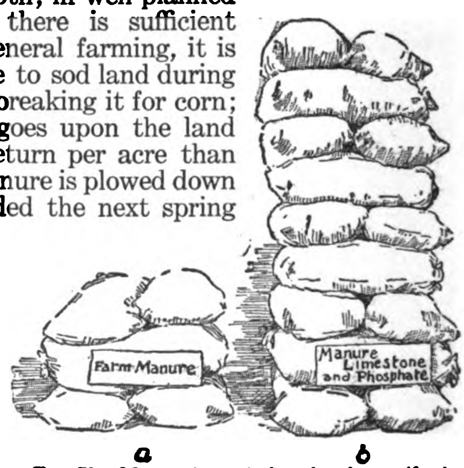


FIG. 70. Manure is good alone but better if reinforced with fertilizers, especially phosphate. These are the yields of wheat from two acre-plots so treated.

How much manure to use. Gardeners and truckers often find it profitable to make very heavy applications of manure—40 tons or more per acre. The large receipts from high-priced crops near a good market justify this practice which is wasteful so far as plant food is concerned. In general farming the largest return per ton of manure is obtained from light applications. The 30 years' experiment at the Pennsylvania Experiment Station is conclusive on that point, 8 tons of manure in the 5-years' rotation bringing more profit per ton than the 12-ton application, and the latter more than the 16-ton dressing. Experiments at the Ohio Station teach the same truth. It is decidedly better to use 6 tons of manure per acre on land to be planted with a general crop, and to extend the application over the entire field, than to apply 12 tons of manure to half of the land and leave the rest dependent upon commercial fertilizer alone. This is because of the presence in the manure of organic matter that affects the physical condition of the soil, provides a mulch when used as a top-dressing, and promotes necessary bacterial action in the soil.

Reinforcing manures. Stable manure is relatively rich in nitrogen and poor in phosphorus, which is in scant supply in practically all normal soils of this country. Thus manure has its effectiveness increased greatly by the addition of acid phosphate, or some other carrier of phosphorus. The Ohio Experiment Station, in a 15-year test, found that the addition of 40 pounds of acid phosphate to each ton of manure, in an application of 8 tons per acre in the rotation, gave an increased value to the manure of $1.51 per ton above the cost of the treatment. The practice of using stable manure alone in general farming should be discontinued wherever soils are of normal type; it is reasonable to expect that the addition of 40 pounds of acid phosphate will increase the efficiency of a ton of manure, used in a moderate application, 50 per cent (after deducting the cost of the acid phosphate). The acid phosphate is used preferably in the stable, care being used to prevent injury to the hoofs of animals, but it may also be mixed with the manure immediately before it is drawn to the field.

How to handle manure. Manure should be made upon water-tight floors, and it rarely is advisable to separate the liquid from the solid by means of cisterns; absorbents should be used to take up the liquid material. The difficulty of holding manure for any time without loss makes it advisable that the manure be drawn out and spread as fast as made, if there is a field ready to receive it. There is considerable danger of loss if manure is spread upon land coated with ice, but this is an exceptional condition, and the soil is so good an absorbent that the loss from immediate spreading rarely is comparable with

FIG. 71. Spreading manure by hand is slow but satisfactory if carefully done. The main thing is to get it out on the land promptly.

the loss that attends storing, even under the best conditions.

The full efficiency of manures, like that of commercial fertilizers, depends in high degree upon their even distribution. Spreaders do the work well, and experience has led to the belief that 8 tons of manure, spread as evenly as possible by use of a machine, will give as good results in the crop to follow as 12 tons of manure applied carelessly with a pitchfork as is commonly done. It is important that every square foot of the surface receive its share of the plant food, and of the physical improvement that organic matter produces. When a spreader is not available, the work should be done as well as possible by hand, and the coat of manure should then be made fine by a heavy brushing or harrowing. Among the methods of application that are absolutely and always wrong, is that of putting the manure into small piles, to be distributed later with a fork. Drenching rains carry the best of the manure into the ground at the base of these piles and very often some heating permits ammonia to escape into the air.

Manure sheds. If the manure cannot be drawn and spread as fast as made, means should be provided to protect it from leaching rains, to keep it moist and to keep out the air. An absolutely tight floor is not so necessary in the manure shed as in the stable, because in the shed the amount of moisture is controlled, but a concrete floor is to be advised. A good plan is to enclose three sides of the shed, so that there will be no drafts, and to use it as an exercising place for cows or other livestock. Such an enclosure is healthful and

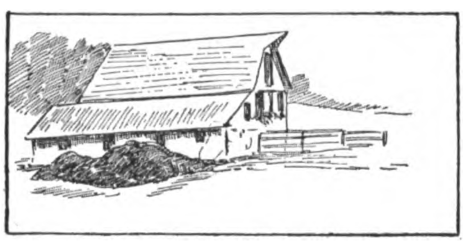


FIG. 72. A common, but wasteful method of keeping manure that hurts the farmer as well as the farm.

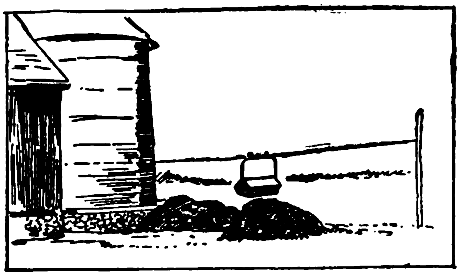


FIG. 73. A manure carrier makes it easy to keep the barns clean, but manure piled out in the open is wasted even more than if left in the stalls.

comfortable, no matter how cold the weather may be, and gives the animals freedom of movement. The manure taken from the stalls each day should be scattered evenly over the surface, and the mass kept firm by the tramping of the animals. It may be necessary to add some water at intervals to keep the mass moist; this always is true when the animals have been removed to pasture and the manure is held for midsummer application. Water excludes the air and assists in holding harmful fermentation in check. If the air is excluded by tramping, and sufficient water is given to prevent heating, rotting occurs without serious loss of the fertilizing elements. If stored manure is permitted to heat, the loss is heavy, and if no roof is provided, leaching rapidly lowers its value. The Ohio Experiment Station exposed manure for 3 months in an open lot and, while there was no loss in weight at the end of that time (because of the action of rain water) the value of the manure, according to analyses made at the beginning and end of the period, had dropped from $2.50 a ton to $1.74, showing a loss of nearly one third of its original value. When, under average conditions, the manure is left in the open lot, from winter until midsummer, when it may be drawn to fields in preparation for seeding, the loss in effectiveness is about 50 per cent.

Land plaster (gypsum) formerly was used in stables to preserve manure, and its effect is excellent, but we secure the same result without cost by the use of acid phosphate,

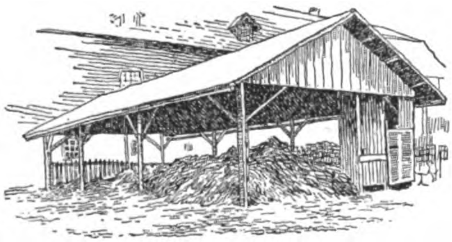


FIG. 74. Protection from rain and excessive heating is the first step in saving manure—provided it cannot be hauled out at once. (See Fig. 76a, p. 79).

since the phosphorus carried is needed to balance up the other elements in the manure and thus repays the purchase price. Common lime never should be used, as it permits the escape of ammonia; this is true also of hardwood ashes.

Preserving poultry manure. Acid phosphate and kainit at the rate of 15 pounds of each to 100 pounds of fresh manure, should be used on droppings-boards in poultry houses to help retain the ammonia, and give a better balanced fertilizer. Dry muck or loam should be mixed with poultry manure to give it good physical condition.

Compost. The gardener or trucker, using a large quantity of manure per acre, often must let some of the fermentation occur before he mixes it with the soil. He wants to reduce the volume of the manure and change its character, so that the power of the soil to retain moisture will be increased, instead of diminished. He can afford to take the trouble of piling the manure with layers of sod, or other material, and of turning it to secure thorough mixing and to control fermentation.

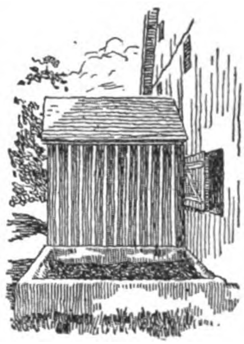


FIG. 75. A concrete pit saves the liquids and keeps all the manure in good condition.

The general farmer, on the other hand, cannot afford the loss that usually attends the rotting of manure in a pile, and if the soil is deficient in organic matter, it is benefited by the incorporation of coarse material with its particles. The compost heap has no rightful place under general farming conditions, but it serves well the gardener and also the small farmer, who may have a cheap source of labor and can use the manure supply to help along the decay of waste materials that are gathered and added to the compost heap. Lime should not be applied to such a heap, but fermentation is encouraged by a reasonable access of air, and undue heating is controlled by the addition of water.

Farm Manures Sometimes Used

Peat and muck. The chief value of muck and peat is in the organic matter they contain. Analysis shows a considerable percentage of nitrogen, but this is in an inert (unavailable) form. The appearance indicates to the inexperienced man a greater fertilizing value than the facts justify. The fertilizing content of muck rarely will justify transportation to any great distance. A bed of muck on a farm can easily have con-

siderable value, as the material can be taken out when farm work does not press, and can be drawn directly to the fields with minimum expense. When dried, it is an excellent absorbent in stables, while the manure helps to increase the availability of its inert nitrogen.

Sawdust. Rotted sawdust makes a strong appeal to the eye, but does not justify much expense in drawing and spreading. If it is not well rotted, the effect of a heavy application upon the soil is distinctly harmful to the physical condition. Sawdust and fine shavings, used in moderate amount as bedding, have not been found harmful to the land, but any material that does not break down readily and that is used in manure that is applied liberally to the land, has a bad effect on moisture conditions.

Sea weeds. Doctor Storer has pointed out that in New England, if we except some isolated tracts of rich land, the really fertile land is "to be found back of those sea beaches upon which an abundant supply of sea weeds is thrown by storms." In Scotland and Ireland, land has been cropped for long series of years without deterioration where the supply of sea weeds is abundant. Sea manure contains a fair percentage of nitrogen and is especially rich in potash. It is not the custom to dry and stack and burn sea weeds in this country, as in portions of Europe; but it *is* spread and plowed in, or else left as a top-dressing.

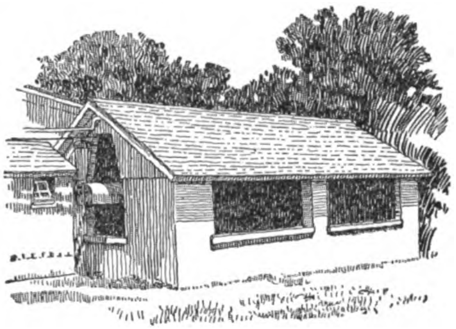


FIG. 76. The best of all ways to store manure is in a concrete, covered shed, from which flies can be screened and in which the manure can be kept almost indefinitely without losing value, especially if treated with phosphate or worked over by hogs.

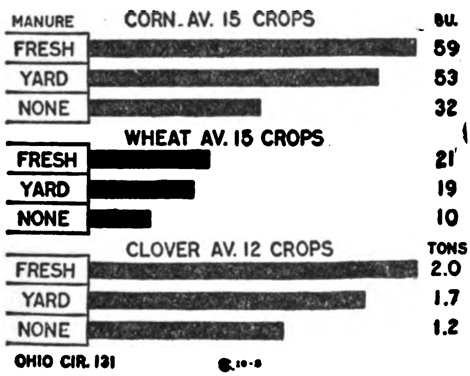


FIG. 76a. Who will deny that it pays to get manure out on the land as soon as possible? (International Harvester Co.)

CHAPTER 7

Commercial Fertilizers

By PROFESSOR ALVA AGEE *of the New Jersey State Agricultural Dept.* (*see Chapter* 6). *Some farmers seem to think of fertilizers as costly, even extravagant, materials that should be used sparingly and only to push highly fertile soils to still greater heights of production. Others consider them the keynote of successful farming, the one factor without which nothing can be accomplished, and with which nothing else is needed. Both views show a misunderstanding of the true facts —the facts which Secretary Agee lays down and explains in this chapter.*—Editor.

A NORMAL soil is composed largely of material that will never be used directly in feeding plants. It sustains the plant physically, holds moisture for it, and furnishes conditions under which its plant-food becomes available. The percentage of material in the soil that plants actually use is very small, but absolutely essential. The plant requires a variety of elements, and if even one of them is lacking, of course the plant cannot be produced. We are not interested in some of these elements, because they are abundant in every normal soil. We are concerned only with the mineral elements—phosphoric acid, potash and lime—that may be lacking in available form, and with the nitrogen which must be stored in the soil, although it came originally from the air. We do not find these elements in their pure state, but in combinations, and should learn their names and know their characters as well as we know the names and characters of the various cereals we grow.

A commercial fertilizer is a source of supply of one or more of these elements essential to plant growth, offered on the market to help out the limited stock found in many soils. It is as surely a source of plant food as stable manure has been found to be. It is a means provided by nature to keep in productive condition all land that would have ceased to produce freely as soon as its supply of any element in available form had been reduced unduly by the removal of crops.

Commercial fertilizers differ from manures in that they furnish little or no organic matter. Since humus is necessary to a soil, disappointment must result from the use of commercial fertilizer if no provision is made for adding organic matter as well. Hence fertilizers supplement stable manure, or sods and cover crops, but do not take their place. At the same time when rightly chosen for a soil, a fertilizer renders a service that stable manure could not, in providing all of the phosphoric acid, or potash, or lime that is required.

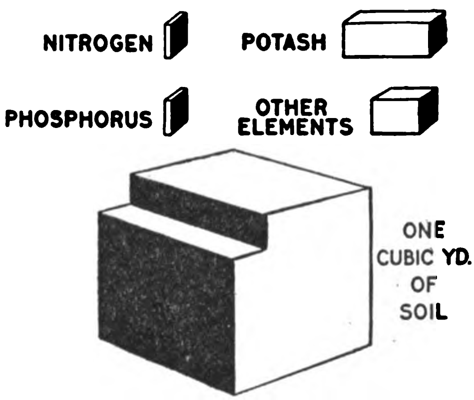


FIG 77. The amounts of plant food in an average fertile soil. (International Harvester Co.)

Nitrogen Fertilizers

Nitrogen is an element so closely concerned with the growth of stalk and

leaves of a plant that we safely estimate its supply in the soil by the appearance of the plants. It is the element that makes possible the broad leaf and dark color of crops taken from fertile land. All worn soils are deficient in this element, which comes from the air and is stored in the soil, but rapidly leaves it through the removal of crops, leaching, etc.

Nitrate of soda. One of the best sources of this element is nitrate of soda, which is imported from South America. It is soluble in water and contains a little more than 15 per cent of nitrogen. While peculiarly adapted to the use of gardeners and truckers, it is also effective in fertilizing staple crops. The quickness with which it dissolves formerly led to warnings respecting loss by leaching when applied ahead of the time the crop would be ready for it; but experience has shown that it is a safe source of nitrogen in fertilizers even for staple crops, *except* on land abnormally subject to leaching.

Sulphate of ammonia. This by-product from the manufacture of coke and illuminating gas contains about 20 per cent of nitrogen, which is in a quite available form. The tendency of this sulphate to exhaust lime in the soil must be recognized, but the amount of lime so taken is not large, and wherever lime is occasionally applied to maintain soil fertility generally, this objection to sulphate of ammonia has little weight.

Dried blood. There is no more satisfactory source of nitrogen than dried blood of high grade which contains nearly as much nitrogen as nitrate of soda and in very available form. The lower grades run low in nitrogen and contain a few per cent of phosphoric acid. All grades are dark in color and should never be bought without a guaranteed analysis. The sentiment in favor of this organic form of nitrogen is so great, that the price often is unduly high inasmuch as an inorganic form such as one of those just mentioned is just as dependable.

Tankage. Another source of nitrogen is the waste from the slaughter of animals, which is cooked for the removal of the fat and then ground. It varies in nitrogen content according to the amount of meat in the mixture, and also the amount of phosphoric acid it carries according to the amount of bone. Tankage is rightly in high repute, though slower in action than nitrate of soda. Its physical condition makes it excellent for use in fertilizer mixtures.

Fish. The organic character of fish fertilizer, and the good results from its use, make its price relatively high, but large quantities are used on our seaboards, the material being ground after the oil has been extracted.

Manufactured compounds. Practical mechanical processes have been devised by means of which the nitrogen of the atmosphere can be converted into a form available for use as plant food. The amount of such products will increase.

Unavailable forms. There are some sources of nitrogen which have little agricultural value on account of the unavailability of the plant food. The nearly universal need of nitrogen in our soils, and the inclination of farmers to demand its presence in fertilizers, has led to considerable use of muck and various wastes from manufacturing processes that hold the nitrogen in insoluble form. The cost of this element is always so great that one cannot afford to buy a form that will not become reasonably available within the growing season.

The use of nitrogen. The farmer is a manufacturer converting raw materials into finished products, and his profit depends upon the wisdom shown in securing the needed raw materials. He cannot secure any growth of plants without nitrogen, yet it is the highest-priced element purchased in a commercial fertilizer. He must decide how far he can profitably go in the feeding of livestock, so that farm manures may furnish some considerable part of this plant food, or else he must make legumes a leading means of supply. The clovers, vetches and other legumes can add large amounts of nitrogen directly from the air by means of bacteria, but time is required for this work, and the problem always is to determine the least expensive, or most profitable, method of obtaining this raw material.

When a field, prepared for planting, lacks a supply of available nitrogen to produce a vigorous growth of plants from start to finish; and when it has been decided that the planting shall be made, the question is not whether there was failure in the past to apply manure, or to grow legumes, but rather how can the soil's immediate needs be met.

Special crops, such as potatoes and other vegetables, repay somewhat lavish feeding, and it is common practice to use nitrogenous fertilizers on them. In normal times, a grower of potatoes may use 50 to 60, or more, pounds of nitrogen per acre, supplied in the form of nitrate of soda, sulphate of ammonia, tankage, etc. On the other hand, 6 or 8 pounds of nitrogen supplied by nitrate of soda, is usually enough to give a good start to corn or wheat, after which the roots are able to extend well into the soil, where other sources of nitrogen may be found. During the World War, the use of nitrogen must be restricted, regardless of the soil's needs. For the supply is insufficient and the prices are nearly prohibitive so far as its use on crops that are not peculiarly remunerative is concerned.

Phosphoric Acid Fertilizers

Phosphoric acid, or the phosphorus which is the base of this compound, is in small supply in most American farm soils. It is neither more nor less essential than nitrogen or potash, but the fact that nature stored relatively small amounts in our soil makes the commercial sources of supply specially important. Phosphoric acid affects plant life peculiarly from the beginning, forcing a growth of roots that enables the plant to feed in the soil. It also hastens maturity and affects most favorably the development of the seed. We may have sufficient nitrogen to give a strong growth of stalk and leaf, and still fail to get a correspondingly large yield of grain (or of tubers in the case of the potato) through lack of available phosphorus. The nearly universal need of this element in our soils has caused farmers to turn first to phosphates when the original stores of soil fertility have been partially exhausted.

Animal bone was the original source of phosphoric acid as a fertilizer, and nothing is more satisfactory; but if all animal bone were carefully saved and spread on the land that produces our animals it would return to the soil only what those animals carried away in their bones, and that is but a small fraction of the draft our crops make upon the soil's supply of this one substance.

Raw bone. The action of raw bone is necessarily slow, as the fat in it prevents fine grinding, and protects the coarse particles from decaying. It is known as bone meal, or coarse ground bone, and a good quality may contain 4 per cent of nitrogen, and 20 to 25 per cent of phosphoric acid. There is a wide variation in quality, and purchase always should be made upon a guaranteed analysis. Raw bone is excellent for fertilizing land seeded to grass, but it is not quick enough in action when an immediate supply of nitrogen is wanted.

Steamed bone. When animal bone is boiled, or steamed under pressure for the removal of fat and nitrogeneous substance, the amount of nitrogen is reduced, and the percentage of phosphoric acid correspondingly increased. The nitrogen in steamed bone may run as low as 1 per cent, and the phosphoric acid as high as 30 per cent. Again composition is variable, and purchase should be made only with a guarantee. The boiling makes fine grinding possible, and there is reasonably quick decay in the soil. Such bone is an excellent source of phosphoric acid, but the price is relatively high, on account of its popularity.

FIG. 78. The effect, on the yield of corn, of the addition of phosphate to an acid prairie soil. Corn on the right from the treated plot. (Wis. Bulletin 230).

Rock phosphate. While the deposit of phosphorus in normal soils is small, we have a relatively large store of it in rock deposits. Those now chiefly drawn upon in this country are in South Carolina and Tennessee. This rock varies greatly in its phosphoric acid content. When to be ground and applied directly to the land (without being treated with sulphuric acid to make the plant food available) a grade running 28 per cent phosphoric acid, or less, is usually selected, the higher grades being reserved for the acid treatment. This untreated rock, ground very fine, often is known as *floats*. It is believed by one group of scientists that a pound of the needed available phosphoric acid can be secured through a very heavy application of finely-ground raw rock more cheaply than through the purchase of acid-treated rock, known as acid phosphate. The theory is that the finest portion of the application provides enough available plant food for immediate needs, and that organic acids render coarser portions available in later years, if manure or green crops, plowed down, are well mixed with the floats.

On the other hand, a majority of our leading soil scientists do not believe that the coarser portions of the raw rock gain much availability as time goes by, and that the untreated rock is not as cheap a source of plant food as rock that has had the cost of acid treatment added to it. There is not space

here to cite the results of tests made over a series of years by various experiment stations; and the writer, basing his statements upon the judgment of a majority of our scientists, can only say that it appears that when the ratio between the price of raw and acidulated rock is normal, the untreated rock will not supply the needs of our soils for available plant food as cheaply as the treated rock will do.

Acid phosphate. Our chief source of phosphorus is acidulated rock ("acid phosphate") made by using nearly equal weights of sulphuric acid and raw rock phosphate. In the resulting material the greater part of the phosphoric acid is immediately available. It has been the common practice to label the bags "bone phosphate" or "dissolved bone." on account of the popular prejudice against the rock as a source of plant food. The combination of sulphuric acid with rock phosphate produces sulphate of lime (gypsum or land plaster) and the buyer may roughly estimate that he is getting two thirds of a ton of this material, along with the available phosphoric acid for which he pays when buying a ton of phosphate. Acid phosphate is an excellent source of available phosphoric acid, but the land receiving it (or any other form of commercial fertilizer) requires the addition of organic matter in the form of sods or manure. The high grade acid phosphates on the market contain 14 to 16 per cent available phosphoric acid.

FIG. 79. The increased yield (*at left*) from the use of $3.50 worth of potash per acre. 150 pounds of potassium chloride gave a yield of 15 tons of silage corn; without it only 3 tons obtained (Wis. Bulletin 205)

Basic slag. When steel is made from iron ores containing much phosphorus, the use of lime gives a by-product called basic slag that has agricultural value because of its phosphorus content. Germany has been a main source of supply, the slag containing 17 to 18 per cent of phosphoric acid, which had a fair degree of availability.

Potash Fertilizers

Land deficient in organic matter ordinarily is lacking also in available potash, although clay and shale soils contain large amounts in unavailable forms. Most sandy soils, too, are scantily supplied with this element of plant food. Wood ashes were formerly an important source of potash, but are now in small supply and usually of low quality, the potash content ranging from 5 down to 2 per cent.

Muriate of potash. Mines in Germany contain a nearly inexhaustible supply of potash in various compounds, and before the war importations of muriate of potash (carrying about 50 per cent actual potash) were heavy. This form of potash is believed to injure the quality of tobacco and sugar beets, but while available it was the cheapest and best source for most staple crops.

Sulphate of potash. The physical condition of the sulphate commends its use in mixed fertilizers. It carries about 50 per cent of potash and the fact that it favors quality in tobacco and a few other crops creates a demand that results in a price several dollars a ton higher than that asked for the muriate. As a rule, it has no higher agricultural value.

Kainit. This, a crude product of the German mines, contains 12 to 13 per cent of potash. It is a sulphate, but one third of it is common salt, and in its effect upon quality it is classed with the muriate. The low content of plant food confines its use chiefly to regions near the seaboard.

Experimental work indicates that the United States will eventually be able to obtain potash in commercial quantities from feldspar (a mineral) and also from kelp, but no large or important supply has yet been secured.

FIG. 80. The wheat at the left was not treated; that at the right, planted at the same time and otherwise handled the same, received acid phosphate and an application of potash fertilizer. (Mo. Bulletin 147).

Salt. This is not a direct fertilizer, but some soils have been made more productive by the application of 200 to 300 pounds per acre, well mixed in the seedbed. Experiments to determine its value in replacing potash have had negative results, and in some instances germination was injured.

Coal ashes. There is no plant food of value in coal ashes, but they conserve moisture when used as a mulch around bush fruits, and are useful in the improvement of the physical condition of heavy soils when applied in large amounts.

Complete Fertilizers

The word "complete," as applied to a fertilizer, has been given a special meaning and is supposed to apply only to fertilizers containing nitrogen, phosphoric acid and potash. As a matter of fact, a complete fertilizer for any soil is one containing the element, or elements, lacking in that soil, and in proper proportion to each other. A phosphatic fertilizer, containing only phosphoric acid, may be a complete one for the field that has received its nitrogen from clover or stable manure, and continues to supply its own potash freely. Again, a fertilizer containing only phosphoric acid and potash may be complete for a muck soil, or for a sandy soil that has been well manured. A worn soil usually is deficient in all 3 forms of plant food, and a fertilizer containing nitrogen, phosphoric acid and potash in varying quantities may be purchased on the market, or mixed at home by use of the materials we have described, which are the chief sources of supply to manufacturers.

It is rarely advisable to buy a complete fertilizer containing only 1 or 2 per cent of nitrogen, phosphoric acid or potash, since the amount present in a ton is too small to justify the price usually asked. If land needs purchased nitrogen, the fertilizer should contain at least 3 per cent, and for sandy soils 4 to 5 per cent is better. If there is a potash requirement in the soil, the fertilizer should contain at least 5 per cent. It was formerly a common practice of vegetable growers to use goods containing 10 per cent potash, but experience indicates that this amount is excessive, and often retards the growth of vegetation. The percentage of phosphoric acid always should be high in a commercial fertilizer for a normal soil, and the buyer does well to demand 8 per cent in high-grade complete fertilizers, and 10 to 12 per cent where the amount of potash and nitrogen is cut down.

Manufacturers' guarantees. State laws require that a statement of the analysis of a fertilizer shall be printed on the bag in which it is offered on the market. There often are unnecessary and confusing statements added to those required. The purchaser is interested only in the actual guaranteed percentage of nitrogen (or ammonia of which 1 pound or per cent is equal to .82 pounds or per cent of nitrogen), of actual potash, and of available phosphoric acid, except in case of untreated goods, like raw bone, when only the total phosphoric acid is given. If there are two columns of figures on the bag, he should disregard the second one, which is not guaranteed. He should also disregard all items in the guaranteed column, except the three or four just mentioned.

If a fertilizer under consideration contains 3 per cent of nitrogen, a ton of it supplies 60 pounds of that element (1 per cent of 2,000 pounds being 20 pounds, and 3 per cent being 60 pounds); if it guarantees 10 per cent of available phosphoric acid, it supplies 200 pounds of that plant food; and if it guarantees 6 per cent of potash, it supplies 120 pounds of that. Thus the greater part of even a high-grade fertilizer is only the carrier, or raw material, with which nature had combined the needed plant food; thus, too, this high-grade fertilizer supplies only 380 pounds of actual value. However, it would have been impracticable to eliminate the worthless material. On the other hand, many low-grade fertilizers carry an imposing analysis on the bag; if the needless figures are disregarded as suggested above, the inefficiency and true value of the mixture quickly become evident.

Valuation. During the World War no scale of values has remained constant for any length of time: prices have advanced rapidly. The following method of making a rough estimate of the value of a fertilizer is based upon prices prevailing in many sections of the country a few years ago, prices which, we hope, may return when conditions again become normal:

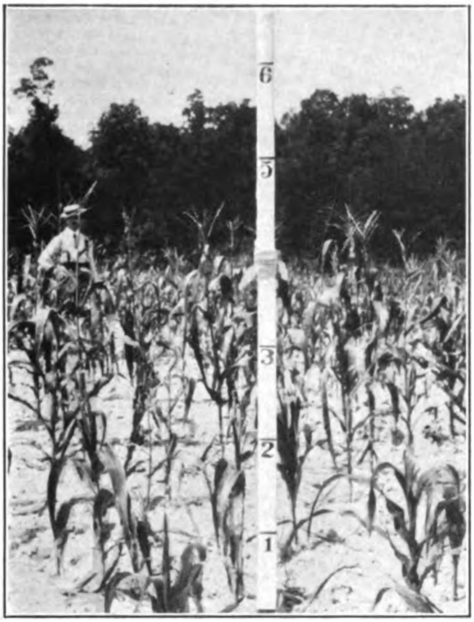
A ton is 2,000 pounds, and one per cent of this is 20 pounds. It is the practice, for convenience, to call 20 pounds, or one per cent of a ton, a unit, and to base the price of the nitrogen, phosphoric acid, and potash, on the unit.

Nature's manure is humus, of which the best example is the forest leafmold

Farm manure is rotted organic matter. It must be so handled as to prevent loss

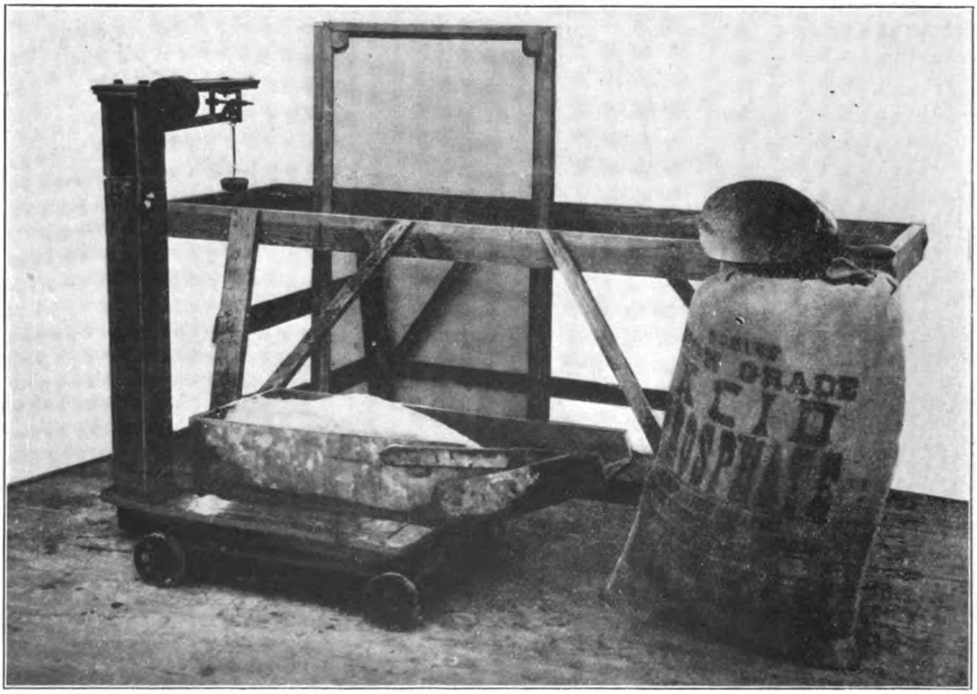
A crop like this tells of abundant plant food in the soil. Barnyard and green manures, lime and careful soil management keep up the supply

MANURE HAS BEEN THE FOUNDATION OF SUCCESSFUL FARMING SINCE THE WORLD BEGAN—AND WILL BE TILL ITS END



This is the crop that grew upon an untreated, sandy, southern soil—

This soil, the same at first, received a little nitrogen, phosphoric acid and potash



Fertilizers are concentrated foods; they should be fed to soils as carefully and accurately as cottonseed meal is fed to dairy cows ·

The Farmer's Problem is to Discover How Much Fertilizer He Must, and How Little He Can, Use on Each of His Fields

If 5 cents is a fair price for a pound of available phosphoric acid in one's locality (as it would be if a ton of 14 per cent acid phosphate cost $14) a 20-pound unit is worth $1. Each one per cent of phosphoric acid guaranteed is thus worth one dollar, and the total amount in the fertilizer is easily valued. If a pound of potash in a ton of muriate is worth 5 cents in one's locality (as it would be if a ton of muriate cost $50, the muriate being one half actual potash) each unit of 20 pounds of potash, and therefore each one per cent of guaranteed potash, is worth one dollar. If a pound of nitrogen in the form of nitrate of soda is worth 17½ cents a pound in one's locality (as it would be if a ton of nitrate of soda cost $54) a unit, or one per cent, is worth $3.50, and the content of nitrogen is easily valued.

As matters stand, the commercial value of a pound of nitrogen may be determined by securing a quotation on a ton of nitrate of soda and dividing that by the number of pounds of nitrogen in a ton, or by using quotations on sulphate of ammonia, dried blood, or some other carrier of nitrogen whose guaranteed analysis is known. In respect to phosphoric acid, this same method may be employed, the asking price of a ton of acid phosphate, guaranteed 14 per cent available, being divided by 240, which is the number of pounds of available phosphoric acid in a ton of such goods. In this somewhat crude way we may determine the commercial value of plant food in unmixed material. In buying mixed goods we should make allowance for the cost of mixing and of selling, taking into account the fact that the goods may be offered on easy terms of payment, and, on the other hand, bearing in mind that some of the material may not furnish plant food in a quickly available form.

The Use of Fertilizers

Home-mixing. The home-mixing of fertilizers is a simple piece of work. Many of the heaviest users of fertilizers buy their materials and mix at home, in order that they may know exactly what goes into the fertilizer, and also that its final cost may be as small as possible. The treatment of bones and rock with sulphuric acid is a separate business that should not be undertaken by a farmer, but he may buy acidulated bone, or rock, just as the manufacturer does, though in smaller quantities.

In mixing fertilizers at home, the farmer first determines the percentage of nitrogen, phosphoric acid, and potash that he wants in his fertilizer for any particular field or crop. Then with a knowledge of (1) the composition of each kind of raw material; (2) the cost per pound of the plant food it contains; (3) the degree of availability of the plant food and (4) the effect of the material upon the physical condition of the mixture, he orders his goods.

FIG. 81. Spreading fertilizer with an end-gate seeder type of distributor

It has been the rule in normal times that nitrate of soda furnishes the cheapest pound of quickly available nitrogen, acid phosphate the cheapest pound of available phosphoric acid, and muriate of potash the cheapest actual potash. However, these materials used alone give too wet a mixture and one that hardens quickly. Moreover, the user may prefer to have some of the nitrogen from a source that yields up the plant food more slowly during the growing season. It is, therefore, good practice to supply only half of the nitrogen as nitrate of soda, a fourth, or more, as sulphate of ammonia and the remainder as tankage, or steamed bone, which gives good physical condition to the mixture and provides nitrogen later in the season. The tankage and bone likewise furnish phosphoric acid and thereby reduce the amount of acid phosphate needed. As the analysis of each ingredient is known, the number of pounds of actual plant food which a proposed quantity will contribute to the total mixture is easily calculated, and each 20 pounds of such plant food becomes one per cent in a ton of the mixture. Bulletins or other detailed directions as to just how to work out such problems can be obtained without cost from many state experiment stations or departments of agriculture. Since they deal with local conditions and materials they are of more help than a general or theoretical example would be.

How to mix fertilizers. The various materials are put into a pile on a clean floor. It is best to use the bulkiest material for the first layer in the pile, and that ordinarily is acid phosphate. A right amount (by weight) to give the total number of pounds available phosphoric acid wanted in a ton of the mixture, less the amount of phosphoric acid contributed by a few hundred pounds of tankage, or steamed bone, is spread on the floor. Then the materials supplying the nitrogen and potash are spread evenly in layers on the pile, the exact weights being determined with scales. If the total weight of the three or four materials does not come to a ton, a sufficient amount of "filler" in the form of dry muck, or loam may be used; a better plan is to make such changes in the proportions of acid phosphate and steamed bone, etc., as to bring the

total weight to approximately 2,000 pounds. The mass should be shoveled over carefully three times to secure even mixing, then be passed through a screen and bagged.

The claim that factory-mixing alone gives a chemical combination of plant food necessary to effectiveness is not well based. Tests have shown that home-mixtures are just as effective as factory-mixed goods having the same analysis. There is no danger of any harmful action resulting from the use of the materials described, but caustic lime, or wood ashes, never should be used in a mixed fertilizer.

Fertilizer requirements. If a soil is rich, and the climate right, the soil will produce most crops successfully; if it is thin, it needs to be made rich. In practical farming, the quantity of fertilizer that may be applied per acre is limited by the market price of the product. Vegetables may give a return several times greater than corn or wheat, and therefore justify a much heavier application of fertilizer. Most vegetables make a rapid growth, which is a sign of heavy fertilizer requirements. Plants valued for their leaf development need large amounts of nitrogen as well as potash, and root crops need a high percentage of phosphoric acid along with good quantities of nitrogen and potash. As a rule, the garden which is dependent chiefly upon commercial fertilizer for plant food should receive a fertilizer containing 4 per cent of nitrogen, 8 per cent of phosphoric acid and 5 to 6 per cent of potash, and the application should be at the rate of 1,000 to 2,000 pounds per acre. A thin soil devoted to a leafy crop should have more nitrogen, which is best given in the form of stable manure. A root or grain crop, on land of moderate fertility, should have the nitrogen cut down to 3 per cent and the phosphoric acid

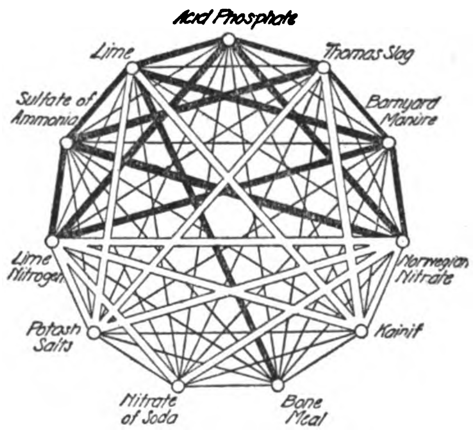


FIG. 82. The heavy black lines connect materials that *must not* be mixed; the light black lines join materials that can be mixed at any time; the white lines show which materials can be mixed if to be immediately spread on the land. (U. S. Dept. of Agr.)

increased. Leguminous crops planted in a fertile soil should not receive much nitrogen. Gardeners and truckers prefer to apply 20 to 30 tons of manure per acre on land to be devoted to vegetables, and then use fertilizers rich chiefly in phosphoric acid, but carrying some potash.

When fertilizers are scarce. During the World War, the supply of potash was small; the supply of nitrogen was inadequate; and the demand for sulphuric acid limited the production of acid phosphate. Prices remain far above the old level. The producer of food knows that his greatest need is phosphorus, and makes acid phosphate, animal bone, and other carriers of phosphorus his first consideration because of its necessity and the possibility of securing the needed amount. Heavy fertilization with acid phosphate insures the freeing of some unavailable potash in the soil, and stimulates such root development of the plants that they can make freer use of the nitrogen in the soil.

The potash need is met in some degree by the saving and using of all liquid manures and the straw, corn stalks and other refuse naturally rich in it. The nitrogen supply is supplemented by the careful preservation of all manure and the growing of legumes. Bare land in August should be seeded to crimson clover, alfalfa, winter vetch, or some other legume to be plowed down the next spring. The soybean and cowpea add nitrogen to the soil rapidly when seeded in early summer. Organic matter of any kind, thoroughly mixed with the soil, adds to fertility. Thorough tillage, to free inert plant food, to hold soil moisture, and to favor the full root growth of the plant, is a most important means of drawing effectively upon the plant food stores in the soil during times of shortage of commercial fertilizers.

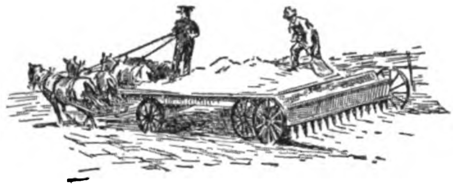


FIG. 83. Spreading lime from a wagon by means of a special distributor

CHAPTER 8

Lime: Its Forms and Uses

By PROFESSOR ALVA AGEE *(see Chapter 6). Soil conditions that make the use of lime necessary or advisable, and the ways in which it improves them, have been touched upon in Chapters 2 and 3. The subject of this chapter is the lime itself, together with the forms in which it occurs and the ways in which the farmer can make best use of them. In the light of modern knowledge, there should be no failure to understand and appreciate its threefold value—first, as a corrective of a soil deficiency due to excess acid; second, as a releaser of locked up plant food; and third, as a carrier of an important plant food element lacking, to a greater or less degree, in many soils. Professor Agee's discussion should render it easy for any one to arrive at a clear understanding of the subject, or a broader, clearer conception of the knowledge he already possesses.*—EDITOR.

WHAT lime is. While most farmers have a single and definite understanding of what lime is, they should appreciate the fact that the word may actually be applied to several different things. As explained elsewhere (pp. 23 and 26, and Vol. IV, Chapter 17) one of the essential elements in plants, and therefore in plant-producing soil is *calcium*. The simplest chemical form in which calcium may exist is the oxide (Ca O) in which it is combined with oxygen and which is really lime. However, the carbonate ($Ca\ C\ O_3$), known as limestone, in which the element carbon is added to the combination; the hydroxide ($Ca\ H_2\ O_2$) or slaked lime in which hydrogen has joined the oxide; and any other chemical combination based on the presence of calcium is a lime material. As pointed out below, these materials differ in composition, availability and effectiveness; for this reason the single word lime tells the farmer very little as to the value of a material, although all of several lime products may be decidedly useful in an active programme of soil improvement.

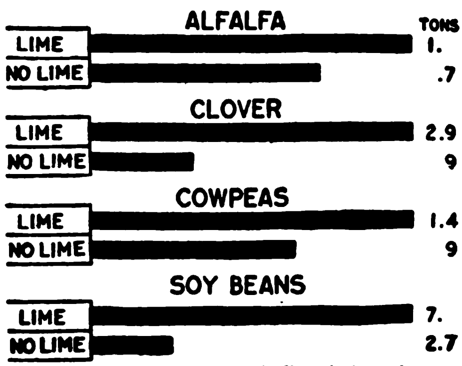


FIG. 84. While the soil needs lime it is useless to hope for good results from legumes. (International Harvester Co.)

What lime does. Lime is nature's active agent in putting and keeping land in such condition, directly and indirectly, that plants may make their most successful growth. It serves as an essential plant food and also provides an active means of keeping the feeding ground of the plant in a sanitary condition. A limestone soil has great natural strength and recovers from mistreatment more readily than land low in lime. It has staying powers and is dependable, unless, through natural processes, the lime leaches out or becomes unavailable. There are soil types illustrating every possible percentage of lime, from that of the

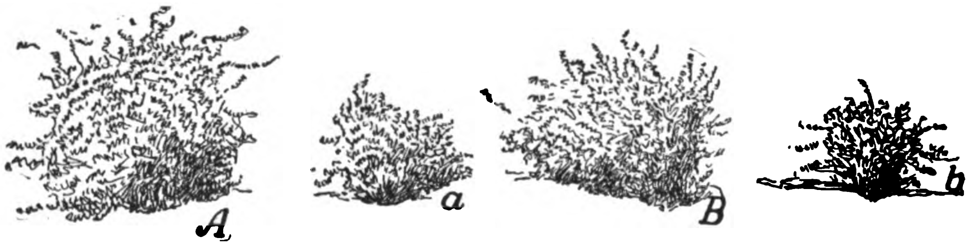


FIG. 85. Some plants prefer an acid soil, cranberry for instance. A indicates the use of sulphate of ammonia, B of nitrate of soda. In each case the capitals (A B) indicate the absence of lime and the small letters (a b) its use. (This and Figs. 86, 93 and 96 from R. I. Bulletin 160).

richly calcareous (limy), down to peat or clear sand carrying little lime or none at all. The actual percentage is not the factor that determines the soil's productive power, since a clay soil needs more lime than a loam, while a sandy soil gives good account of itself with less. But, in its way, either any particular soil type must be well supplied with lime by nature or the deficiency must be made up by man.

The total area of lime-deficient soil is large, comprising certainly more than half of all the land east of the semi-arid part of the United States. Some of this land always was notably deficient in lime, as the character of the original vegetation indicated; other portions were originally fairly well supplied, but have since lost their supply up to a point at which there is marked deficiency.

The old-time practice of making heavy applications of fresh-burned lime to stiff limestone soil was based upon the ability of lime to improve the physical condition of the land and also to make the plant food in the soil available for use. Soil areas of limited extent require applications to furnish actual plant food. However, lime is applied chiefly to correct soil acidity, so that crops which flourish best in an alkaline soil may have full opportunity. Naturally one thinks first of the legumes because the nitrogen-gathering bacteria that are associated with most varieties of legumes require an alkaline soil, or one in which the lime deficiency is slight. Other kinds of bacteria in the soil produce availability in plant food, and a relatively high percentage of lime is necessary to their full activity.

How soils lose lime. A normal soil contains a percentage of lime that came from the breaking down of the rock of the region, or was transported by the action of water on a huge scale. While some of our farm land always had a scant supply, the troubles of our present day, in the case of the farming country in the humid region of the United States, are due less to a natural absolute shortage of lime than to (1) chemical change in the soil that destroys its value, and (2) the escape of lime through action of water. Leaching is a common cause and one that has brought about marked results. There are limestone areas in which the lime has been washed out to such an extent that caverns have formed under the

FIG. 86. New Zealand spinach, in contrast with cranberry, prefers lime (a and b) and nitrate of soda (B and b)

surface; in other cases land has gone down into the acid class merely as a result of leaching.

A serious cause of lime exhaustion is the presence of compounds in the soil that combine with the lime and rob it of the ability to unite with the soil when new acids form. Another cause of increasing acidity in cultivated soils is connected with the decaying of vegetable matter. Many of us have seen fields rendered temporarily unproductive by the plowing-down of a cover crop of immature plants in midsummer. All organic matter in decaying makes a draft upon the lime content of the soil with which it is mixed. The store of soil lime is also reduced by the removal of crops; and a poor circulation of air through the soil furnishes conditions under which acidity increases. Still other causes of loss exist, with the result that there is a constant tendency on the part of the land to lose its friendliness to our staple farm crops, causing lime applications to become increasingly necessary.

FIG. 87. Common weeds found on soils very likely to be acid: *a* Horse-tail rush; *b* Sheep sorrel; *c* Corn spurry; *d* Wood horse-tail. (Wis. Bulletin 230).

How to Know When Lime Is Lacking in Soils

Where such lime-loving plants as red clover and blue-grass do not thrive in a section of the country that should favor them, we may safely assume some lack of lime. Where sorrel and plantain are not crowded out by more valuable plants under good tillage, the better plants are probably held back by soil acidity. The prevalence of red-top grass, where timothy would be preferred, suggests lime deficiency, as does a successful growth of alsike clover, where medium red fails. Chemical tests for soil acidity are easily and cheaply made, requiring only such apparatus as any farmer can obtain. Three such tests are the following:

The litmus paper test is the simplest and has been most widely used. It calls for only some strips of a chemically prepared paper, of a pale bluish color, called litmus paper which may be obtained of any druggist for a few cents. To make the test, take a lump of moist soil, cut a slit in it with a clean knife blade, insert the end of the paper, and squeeze the soil against it. In about 10 minutes remove the paper; if the end has turned, or become spotted with, pink, the soil is acid. This test has a fair degree of dependency, but (a) it does not always indicate a very slight acidity, and (b) it may show a positive reaction when the cause is only the presence of carbonic acid which is given off by the roots of living plants and which does not cause harmful soil acidity.

The muriatic acid test, though simple, is really one designed to show the presence of lime rather than a definite acidity. If this acid, diluted, is poured upon a teaspoonful of soil which contains lime carbonate, a vigorous bubbling takes place; if no carbonate is present there is no such action. The difficulties here are that (1) a soil without lime carbonate is not necessarily acid; and (2) in the case of an acid soil this test gives no indication of the degree of acidity.

The zinc sulphid test was devised by E. Truog, Instructor in Soils in the Wisconsin Agricultural Experiment Station and described in Bulletin 249 of that station. It calls for an alcohol lamp (Fig. 89) or other burner; a shield and frame for holding a boiling flask; a glass measuring cylinder graduated up to 50 cubic centimeters; a metal cup holding 10 grams of clay loam or similar soil; a mixture of chemically pure neutral zinc sulphid (5 grams) and neutral calcium chlorid (50 grams) in 250 cubic centimeters of pure water; and some strips of filter paper that have been soaked in a 10 per cent solution of lead acetate and allowed to dry separately. Any of these chemicals can be supplied or obtained by a druggist and the utensils purchased from, or made by, dealers in chemical apparatus. The solution and test papers must be kept in tightly stoppered glass bottles.

To make the test, measure a sample of typical soil into the cup, even full; put it in the test flask and add 45 cubic centimeters (cc) of water con-

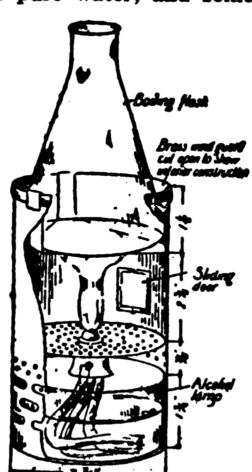


FIG. 88. Lamp and flask used in soil acidity test with frame cut away to show how parts are set up. (See Fig. 89.)

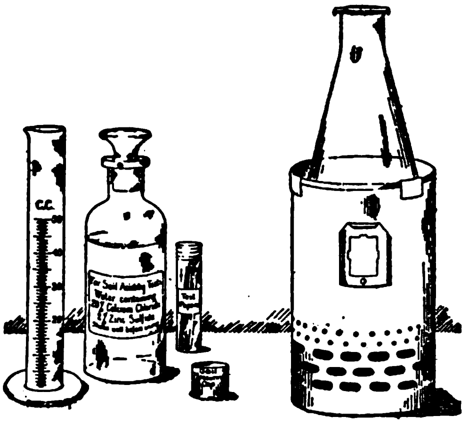


FIG. 89. Complete apparatus for making the zinc sulfid test for soil acidity. (This and Fig. 88, Wis. Bulletin 249).

taining 5 cc of the zinc sulphid mixture; then add 50 more cc of water. Put the flask over the burner, note when the water begins to boil and let it boil for just 1 minute. Then place a piece of the test paper over the mouth of the flask and boil 2 minutes more after which the lamp may be blown out. *If the under side of the paper has darkened the soil is acid.* When the paper is dry, compare it carefully with the color chart supplied with the bulletin (reproduced on page 103) to determine the degree of acidity and, consequently, the approximate lime needs of the soil. Important precautions are to (1) measure the soil accurately; (2) keep the flame steady; (3) shake the bottle of solution before using; (4) not let the flask boil over; (5) clean it immediately after completing the test; (6) shelter the apparatus from the wind; and (7) keep all acids and alkalies (soap) away from the bottles and glassware.

Kinds of Lime

Nature cannot prevent the loss of lime which she has mixed with the soils in the ways mentioned above, but her supply of limestone and other carbonates, carriers of the lime principle, with which this loss can be made up, is inexhaustible.

Limestone. Limestones vary widely in purity. Good stone is more than 90 per cent pure calcium carbonate, and most stone on the market is more than 95 per cent pure. But as limestones were all formed under water, clay and sand were laid down with the lime in such quantity, in some cases, that the resulting stone is not worth handling for soil improvement. Burning and slaking first afforded man a natural means of putting limestone into form for distribution. It is only within recent years that the grinding of raw limestone by machinery has become a business of large size. Very finely pulverized limestone is an effective source of lime for the soil. It can be hauled to the farm when other work is not pressing, stored without possibility of loss, and applied with relative ease because it is in good physical condition for distribution, and is not caustic. The desired degree of fineness in limestone depends upon local conditions. Where the material is costly on account of freight and hauling rates and the application per acre is therefore kept small, immediate availability is wanted, and buyers may stipulate that all the limestone shall be fine enough to pass through a screen having 60 meshes to the linear inch. Wherever the price of the limestone is not high, it is better practice to make a relatively heavy application to supply the needs of the soil over a considerable term of years. In that case, a lot of limestone passing through screen of 8 meshes to the inch will have a sufficient amount of very finely pulverized material to supply immediate needs, the coarser material becoming available later on. Some authorities prefer a still coarser article on account of its cheapness and advise a corresponding increase in the amount per acre.

Freshly burned limestone. Burning and slaking reduce limestone to good physical condition for even distribution on the land. The burned lime is superior to ground limestone in its ability to affect favorably the physical condition of tough, intractable land and render it friable and easy of tillage. This caustic lime also renders the organic matter in the soil more quickly available, and an increase in yield quickly follows an application. This ability to make inert plant food available has led many farmers to think of it, and use it, as a substitute for manure and commercial fertilizer. Because exhaustion necessarily follows this practice, lime sometimes came into disrepute, although undeservedly. It is entirely safe to use burned lime in the quantity needed to correct soil acidity and to supply the small surplus of lime needed for full crops of legumes and other plants that furnish organic matter to the soil. It is only the use of burned lime in unreasonable ;quantities per| acre that need be feared.

FIG. 90. A small kiln for burning limestone on the farm.

One advantage that burned lime possesses

over pulverized limestone is its highly concentrated form. When 100 pounds of pure limestone are burned into lime, 44 pounds of waste material go into the air, and the remaining 56 pounds of pure lime have the same ability to correct soil acidity and to supply lime to plants that the original 100 pounds of limestone possessed. Making allowance for some impurities we may estimate that $\frac{3}{5}$ of a ton of freshly-burned lump lime is the equivalent of 1 ton of limestone so far as beneficial effect to the land is concerned. When freight rates are high, or the haul to the farm is long, the freshly-burned lime may easily be the better purchase, since 3 loads of it are equivalent to 5 loads of the limestone.

A distinct disadvantage is the fact that freshly-burned lime cannot be distributed evenly unless slaked; and when it is slaked on the farm, even distribution with a machine is neither as easy nor as pleasant as the spreading of pulverized limestone.

Hydrated lime is a popular form of commercial lime. To make it, manufacturers burn the stone, driving off the waste material, and then combine enough water with the freshly burned lime to change it to the hydrate form, in this way adding 32 per cent to its weight. It is run through a sieve to remove any coarse material and then packed in bags, which helps to exclude the air. Its good physical condition makes even distribution possible and thus permits maximum effectiveness to be obtained. After all, it is only slaked lime, identical in composition and value with lump or quick lime of the same purity slaked on the farm. The addition of moisture to produce slaking increases weight, so that the original 56 pounds of freshly-burned lime secured from 100 pounds of limestone become 74 pounds of hydrated lime. We have in these 3 forms the same lime content and the same ability to correct soil acidity; the question of which form shall be purchased to give this content and efficiency depends upon the cost per ton distributed in the field and the degree of evenness in distribution that is possible in each case.

Air-slaked lime. When either burned lump lime or water-slaked lime is fully exposed to the air, a chemical change restores it to its original composition as limestone. More weight is added from the air, and the 74 pounds of slaked lime become 100 pounds of air-slaked lime, or nearly so. Air-slaked lime has a high degree of availability and when used in only small quantities per acre is to be preferred to ground limestone that has not been made very fine.

Agricultural lime. Some manufacturers have found in the farmers' demand for lime an opportunity of disposing of much material that would not be satisfactory to manufacturers and builders. In some cases this so-called agricultural lime is sold at a price that is not beyond value, but it varies greatly in its content of pure lime. If the unburned cores of

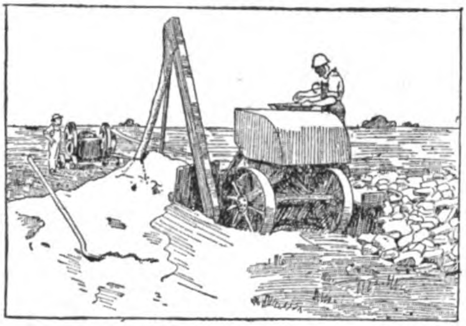


FIG. 91. A small power-driven crusher with which a farmer can grind his own limestone

lime kilns are ground up, the material simply retains the value of unburned stone, and any air-slaked material put into it has like value. Forkings ground up have less value and sometimes none at all. Some better material may go into this mixture that is given the name agricultural lime, but in general it is a product that cannot be standardized or have a value given it in one case that would be true for any other lot.

Magnesian lime. Much of our limestone supply has a high content of magnesium, and there has been much discussion respecting its effect upon land. It is known that a limestone rich in magnesium will correct as much soil acidity as a pure limestone and, indeed, a little more. There is no evidence that magnesium in a limestone has any harmful effect, except in the case of a burned magnesian rock applied in somewhat large amounts upon some types of sandy soil. There is no reason to believe that preference should be given to pulverized limestone free from magnesium, or to a burned lime free from this element except under this last mentioned circumstance.

Marl is a fine, clay-like soil formation carrying a considerable percentage of calcium carbonate and extensively used where abundant—especially in England—in soil management. Marls vary in composition as limestones do, but there are some beds of a chalky marl that contains very little clay and sand, and that is nearly a pure carbonate. It is only such marls of a high degree of purity that can be put on the market with profit, but beds of less pure marl furnish dressing for nearby farms in many sections of the country. The best lime marls provide excellent material for the correction of soil acidity, the actual value per ton being practically the same as that of the finest pulverized limestone.

A lime marl should not be confused with the so-called "green sand" marl, which is low in lime and may even be acid, its value consisting in its content of potash and phosphoric acid.

Oyster shells. Pulverized oyster shell is a carbonate of lime, having practically the same value as pulverized limestone. The supply is

FIG. 92. Yields from limed and unlimed clover hay plots of equal size and similar soil conditions

small, but when available it is an excellent material for use on land. Burned oyster shell lime has something like the same composition as lime from limestone, but it goes back to hydrated and air-slaked forms rapidly, taking on weight without adding to its value.

Hard-wood ashes. As a source of lime, ashes have become too expensive. The composition of ashes on the market is widely variable, dirt and moisture often accounting for much of their weight. Unless analysis is made at time of purchase, the buyer should not estimate the content of lime in a ton at a value greater than that of $\frac{1}{3}$, or $\frac{3}{8}$ of a ton of limestone. The additional value of ashes is due to the potash they contain.

Basic slag. The amount of effective lime in basic slag, as made by modern methods, is so small that its value is hardly worth counting on. It is a good source of plant food and has a slight tendency toward the correction of soil acidity, but such tendency has little cash value for land that requires a considerable dressing of lime.

Land plaster. The soil wants lime in carbonate form. The lime in land plaster is in the form of a sulphate and its tendency is therefore to make a soil acid. It should not be considered as a means of correcting acidity.

How Farmers Can Get and Use Lime

Lime manufacturing plants located where beds of pure stone are easily accessible, find a rapidly increasing demand for their product, but a considerable percentage of American farmers have limestone available at, or near, the surface of the ground on their own property, and some of them are making good use of such supplies. Their one problem is to reduce the stone to such a state of fineness that there may be even distribution. This may be done either by the use of low-priced pulverizers, or by burning and slaking.

Pulverizers. A group of farmers, or a single farmer individual, can buy a machine for pulverizing limestone for a few hundred dollars. Within the last few years much headway has been made in perfecting grinding and pulverizing machines, improved forms of which are now on the market. As a high degree of fineness is obtained only at the expense of power or time, and as the transportation charge on the home-ground product is small, there is no need to work for the degree of fineness wanted in a high-priced article that must be used sparingly. A relatively coarse product from a small pulverizer on the farm will contain a sufficient percentage of fine stuff to take care of the imme-

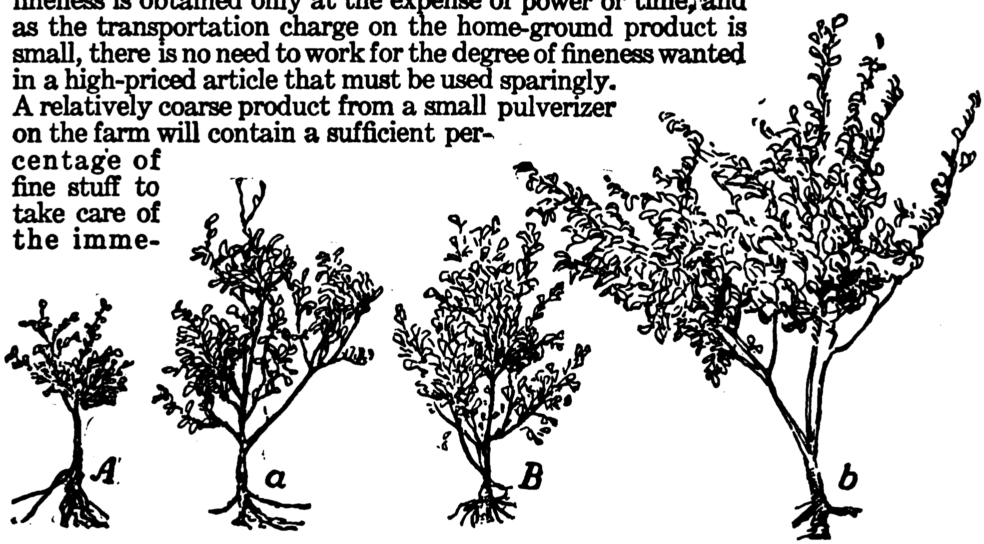


FIG. 93. Lime clearly benefits the orange quince (a and b). Nitrate of soda (B and b) is apparently a better fertilizer for it than sulphate of ammonia (A and a)

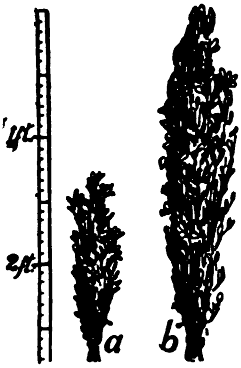


FIG. 94. Bundles of sweet clover showing average growth on unlimed (*a*) and limed (*b*) portions of one field. (Farmers' Bulletin 797)

diate soil acidity, if the application is heavy, the coarser portions becoming available later on. It is not good business to provide facilities for pulverizing all the product very finely, when a coarser product, containing some fine material, may be prepared at half the cost per ton, thus permitting the application of double the quantity per acre.

Burning limestone. The burning of stone has been the chief means of bringing it to a condition in which it is available to the soil, excepting, of course, the vast work of disintegration (breaking down) carried on by nature throughout the ages. The common method of producing lime for farm use is simple and inexpensive, involving the use of merely wood, coal and limestone in layers, with earth as a covering.

Slaking lime. When lime is slaked on the farm, the custom has been to distribute it in small piles in the field, so that spreading could be done easily with a shovel, the lime being slaked by water from rains, or by moisture from the air and earth. This method is wasteful, because distribution is necessarily uneven and an excessive application must be made to insure some portion reaching all parts of the surface of the ground. Oftentimes an excess of water puddles some of the lime in the pile and puts it into ineffective form. A much better method is to put the lime in large, flat heaps and about 4 feet deep and slake it with water from a hose, or let the rainfall do it.

How to apply lime. Pulverized limestone, and lime prepared in hydrating plants, are easily distributed by means of lime spreaders, which may be bought on the market, or made on the farm. Slaked lime is handled with less ease, as it contains some refuse and inclines to pack. Some manure spreaders apply lime satisfactorily when a moderately heavy application is wanted.

It should always be borne in mind that the effectiveness of an application is in proportion to the evenness of distribution. The sidewise movement of lime in the soil is slight, and each square foot of the surface of a field should receive its proper amount.

An application of lime is most effective when mixed with the surface soil. It may be made on grass several months before the sod is to be broken, but the application must then be larger than is necessary when the lime can be thoroughly mixed with the soil as soon as applied. It should never be plowed under. If a seeding of alfalfa, clover or grass lacks lime, it is good practice to make an application broadcast on the surface, because in such a case the lime deficiency should be met promptly; but a given amount of lime will make the

Degree to which various plants are benefited by liming: 3 means greatly benefited 2, benefited; 1, slightly benefited; 0, neither helped nor injured;—1, definitely injured. (from R. I. Bulletin 160).

Asparagus	3	Martynia	2
Australian salt bush	2	Millet	0
Barley	3	Muskmelon	2
Beans	0	Mustard	2
Beets	3	Oats	1
Broccoli	2	Onions	3
Brussels sprouts	1	Parsley	0
Buckwheat	1	Parsnip	3
Cabbage	2	Peanut	-1
Carrots	1	Peas	1
Cauliflower	2	Pepper	3
Celery	3	Potato	0
Chard	2	Pumpkins	1
Chicory	0	Radish	0
Collards	1	Rape	2
Corn	0	Rhubarb	1
Cotton	0	Rowen	3
Cowpea	0	Rye	0
Cress	0	Sainfoin	1
Cucumbers	1	Salsify	3
Dandelion	1	Scotch broom	-1
Eggplant	2	Serradella	-1
Endive	1	Sorghum	2
Emmer (speltz)	2	Sorrel	-1
Flax	0	Spinach	3
Furze	-1	Spurry	1
Gumbo (okra)	3	Squash	1
Hemp	2	Sunflower	1
Horse radish	2	Tares	1
Kale	1	Tobacco	3
Kohlrabi	1	Tomato	0
Leek	3	Turnip	0
Lentils	1	Vetch	0
Lettuce	3	Watermelon	-0
Lupines	0	Wheat	1

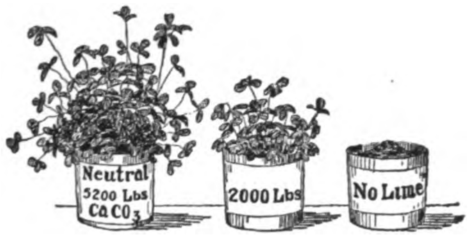


FIG. 95. Test plots of clover showing the effects of applications of lime representing the amounts, per acre, given on the labels. (Pa. Bulletin 131).

largest return for the investment if it can be mixed thoroughly with the soil when the seedbed is being prepared.

A good method is to apply at one time as much lime, or limestone, as may be needed during the crop rotation of 4, 5 or 6 years, and to make this application after the sod has been broken for a cultivated crop, or when the soil is being prepared for seeding down to clover and grass.

How much lime to use. The amount of lime, or limestone, that should be used depends upon the soil, the crop and the cost of the application. Most normal soils that have any acid should be given 2 tons of finely pulverized limestone, or a little more than 1 ton of freshly burned lime every 4 or 5 years. If coarsely ground limestone can be secured at a low price, the application should be twice as great, and it is reasonable to expect that this larger application will last through 2 crop rotations. There are special crops, such as alfalfa, that thrive best when the soil is distinctly rich in lime, and many successful alfalfa growers in our Eastern states apply 4 tons of pulverized limestone before seeding.

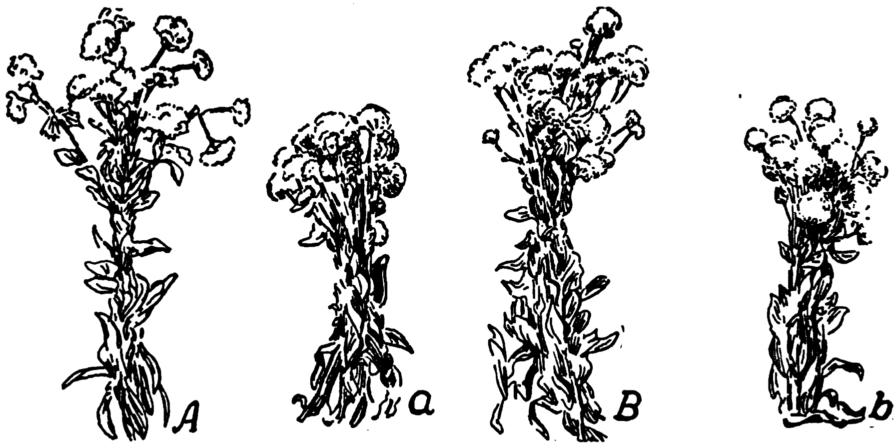


FIG. 96. The familiar catchfly is another plant that prefers the absence of lime (A and B). Sulphate of ammonia (A a) and nitrate of soda (B b) seem equally effective in this case

FARM KNOWLEDGE

VOLUME II—PART III

Systems of Farming in America

WE HAVE seen in Part 1 that soils differ in quality, condition, and usefulness from place to place; that the same soil may vary in condition from time to time; and finally that man has learned how to modify and correct soil conditions so as to make the earth more able to serve his purposes.

Nevertheless, certain soil conditions that he cannot change, climatic conditions, facilities for shipping out products and shipping in supplies, the labor available, the distance to and nature of its markets, and a number of other factors all conspire to make any one region adapted primarily to one type of farming, or at most a few types. The next 11 Chapters discuss regions of the United States each more or less distinct on the basis of agricultural activities. In Chapters 20 to 25, geographical and political boundaries are disregarded, the main types of farming being themselves taken as the subjects of discussion; the principles and conditions under which they may succeed and their opportunities and risks, advantages and disadvantages are there pointed out.—EDITOR.

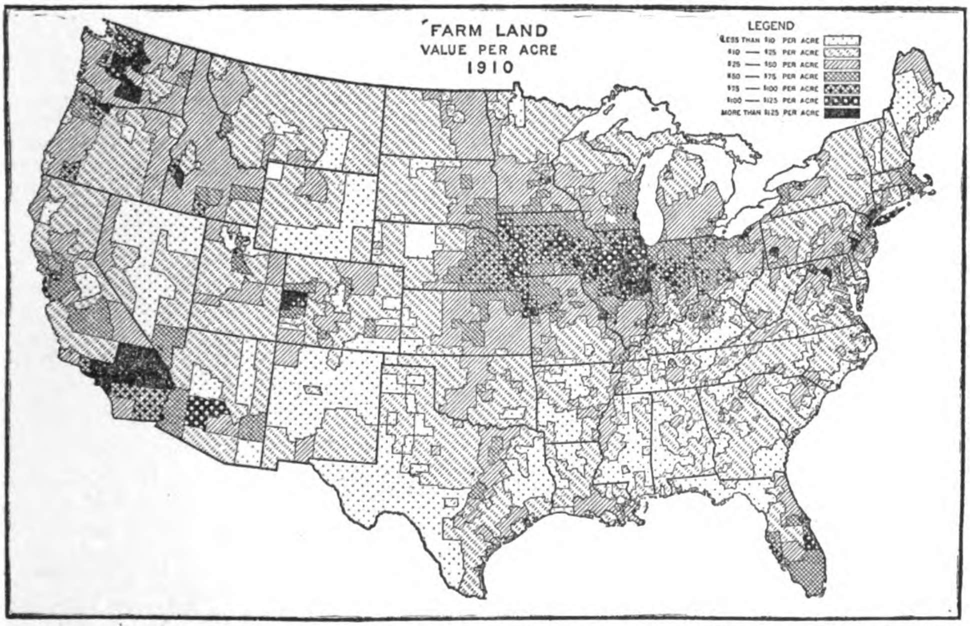


FIG. 97. The value of farm land depends sometimes on its nearness to large cities, as in southern New York; sometimes on its special adaptation to special activities, as in California, Florida, and the Northwest; and sometimes on its natural value for general farming as in the corn belt. In the latter case it is practically permanent and steady. (1915 Yearbook, U. S. Dept. of Agr.)

FIG. 98. A typical New England landscape

CHAPTER 9

Systems of Farming in New England

By LAWRENCE GREEN DODGE, *farmer, of West Newbury, Mass., who was born in the same county on a farm which his family had farmed continuously since before 1650. After becoming familiar with practical farm work at home and elsewhere, and graduating from Harvard University and the Cornell College of Agriculture, he took up the work of the Office of Farm Management of the U. S. Department of Agriculture, remaining with this bureau until 1916, and making an exhaustive study of farming throughout New England, and a more general survey of conditions over much of the rest of the country. Since 1910 he has been running his present farms, giving considerable attention also to coöperation and other factors of successful community agriculture.*—EDITOR.

NEW ENGLAND, comprising the states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut, is unique as far as its farming is concerned. Its location in the extreme northeast corner of the country and its range of elevation give it widely varying conditions that affect its agriculture. Northern Maine reaches farthest north of any portion of the United States east of the Great Lakes while the southern coast of New England lies along the mild waters of Long Island Sound. In fact all the coast of the region has a climate much modified by the ocean, while the interior elevations of the White and Green Mountains are exposed to decidedly low temperatures. Most of the higher lands of the six states are largely forested containing a large proportion of rough land, better suited to forest growth than to farming. However, not all the good land lies in the valleys. In the northern part of New England especially there is much strong, productive crop and grazing land on the tops of ridges and on slopes high up on the hills, arable land lying at elevations of more than 1,500 feet above the sea and good grazing at still higher levels. Forest land is scattered all over the states, but most continuously over the highland running lengthwise of Vermont in the White Mountains region, and in the broken country of lakes, swamps, and hills commonly known as the "Maine Woods." The typical New England farm

includes some rough land best adapted either to pasturing or wood growth. The proportion of such land varies widely; while some farmers have little pasturage and no firewood provided by the farm, others can pasture more animals than they can winter, and are able to get a regular income from firewood and logs.

There are few, if any, sections which need extensive drainage. A single line of tile run from a "springy" spot to the nearest water course or roadside gutter will often prove to be the only form of drainage needed, and very profitable, too.

Soils. These are extremely varied, the whole of the territory having been covered by the ice sheet, and the soils later modified by the action of streams and surface washing. They include coarse river sands as in parts of the Merrimac Valley, and heavy clays as along the southern shore of Lake Champlain, but no very large proportion of either. The greater part of the farm land is composed of soils ranging from clay loam to sandy or stony loam. A greater proportion of the heavier soils is found in the northern part of the region. The difference as related to practical farming operations is largely one of moisture. Northern New England in general enjoys a more generous supply of soil moisture, first, because of a more regular summer rainfall; second, because the soils, on the average, are naturally more retentive of moisture; and third, because the humus supply does not burn out so rapidly as in hotter regions farther south. The soils of southern New England require more care in maintaining the humus supply, but they mature crops earlier and when given the humus will produce heavy yields.

The soil differences are much more closely associated with differences in climate than in most parts of the United States. For instance the more regular rainfall of northern New England is of great assistance to the soils of that section. The longer growing season of southern New England is a great advantage there, provided the soil is so handled in the matter of humus as to take advantage of the longer, warmer summer, rather than to suffer from it.

Climate. In either section the range of temperature through the year is wide; in southern New England it reaches high up in the nineties during the summer and as low as 20 degrees below zero in winter. In the northern portion the summer temperatures are a little cooler and the winter much colder. Parts of northern New England often have no more than 70 days without frost. In this region, however, there are many areas so protected by lakes or other bodies of water, as to enjoy a much longer frost-free season. The corresponding period is longer in all of southern New England, covering 120 days in favorable locations. As a result southern New England is a good corn-growing section, while the crop is an uncertain one in the north, and in some parts there is not grown at all. The rainfall of the whole region usually amounts to from 36 to 42 inches for the year—the north receiving the heavier amount and also a more equable distribution.

The people. New England, and more especially its southern part, is within the most densely populated part of the United States. The first feature to attract the attention of visitors from the West is the frequency of small cities and good-sized towns. In southern New England as a whole but a small proportion of the population lives in the country. The highly well developed manufacturing enterprises have brought in a population of many nationalities, some of which are almost wholly confined to the cities. In southern New England one finds Polish, Scandinavian, Italian, and to some extent, Portuguese, farm workers, with men of the last two races becoming farm owners in considerable numbers. Such families as are attracted to farming have usually come from farming sections of their native lands, are for the most part industrious, and prove an asset to the farming business. Going northward and away from the seaboard one finds a great change in population. Not only are the cities and towns less numerous or much smaller, and the proportion of the population living in the country larger, but the people are far less diverse. The principal addition to the early New England population of English descent consists of immigrants from Quebec and the shore Provinces of Canada, of French Canadian, Scottish, and English descent. In a few localities such as northern Aroostook County in Maine, small groups of Scandinavian people have also become established. With the exception of a very few isolated communities, the people are of a good grade of intelligence and have profited by good schools, and rural mail and telephone service, which are general.

Industries and manufactures. New England early developed certain industries such as shoemaking, thus using during the winter labor employed on farms in summer. This particular industry was carried on for generations in small shops on the farms before the factories took the business. The steep descent from the interior to the sea coast gave streams with a good fall, and the forest cover on the high lands insured a reasonably steady flow of water, producing on the New England rivers, a great amount of water power suitable for textile mills. This power is still extensively used, but often supplemented by steam. The Merrimac River is said to turn

more spindles than any other stream in the world. With these two early established manufactures, and many others grown up among them more recently, the railroads have developed into a network connecting the manufacturing towns and cities with each other, the seaports, and commercial Western centres. The presence of a dense population in southern New England has made good markets for such farm products as the farms of New England can grow and deliver to the consuming centres most economically.

Farming in New England

New England as a whole is recognized as an industrial rather than a farming region because of the early development of manufactures there, together with the broken land surface of much of the section. Its farm land has been compared with such land as that of the Mississippi Valley, and since it is not similarly adapted to large fields of corn and small grains, the idea has become common among farmers of other states and often among the non-agricultural population of these states, that there is no farming in New England. As a matter of fact, farming has a sound economic place in New England, provided the farm business is organized to meet existing conditions.

The natural adaptation of the region primarily to the growth of grass and trees early promoted the development of such livestock operations as depended mainly on grazing for summer and hay for winter feeding. Wool sheep and dairy cattle required the least additional feed to make such a use of the grass lands. For many years following, on account of the growth of the Central States and the beginning of grain growing there, mill feeds of various kinds could be purchased cheaply by the New England farmers, and as a consequence dairy farming became the generally distributed type. Near the larger cities, dairy products were sold in the form of market milk; elsewhere cheese and butter were made on the farms or at small local factories. With the growth of the cities the market milk business has extended throughout New England until cheesemaking has practically ceased and buttermaking has become limited to a few relatively small areas. Wool values also became low and until the past 10 or 15 years the demand for mutton did not warrant the growing of sheep primarily for meat. Before the Corn Belt became the great beef-producing section of the country, some beef cattle were grown and fattened on almost every New England farm. Later this could not be done with economy and for a generation or more almost no beef animals have been obtained from this region, except dairy cows which have become unprofitable as milk producers.

Dairying

For the past 2 or 3 decades the typical New England farm has been devoted mainly to dairying with a few crops usually grown for sale. These were chiefly potatoes, apples, some hay, sweet corn in the canning sections, maple sugar and syrup in the hardwood areas and mixed truck crops near the cities. Small flocks of poultry have usually been kept, chiefly as scavengers, and in the creamery sections enough hogs are raised to utilize the skim-milk. The extensive interest in dairying has probably been in part due to the fact that the care of the herd offered farmers regular employment and additional returns during the winter months. The perishable nature of the product has been responsible for the expansion of the market milk business over New England. Perishable or bulky products have been most profitable for many New England farmers since the impracticability or expense of transporting them from other states has

FIG. 99. Dairying with market milk as the leading product is of great importance

offset any greater cost of growing them which might prevail here. Thus there has developed the growing of enough perishable fruit and truck crops to supply the local demand, the production of milk and sweet cream for market, and the growing for sale of relatively bulky crops such as potatoes and hay. The growing of grain crops of any kind has meantime been largely omitted.

The conditions under which milk has been marketed also have affected the location of the business. Much of the milk supply of the large cities is handled by a few shippers doing an extensive business, who have purchased milk farther and farther from the consuming centres, wherever it might be obtained at lower prices than were possible near at hand. With increasing land values and labor and feed costs, many farmers nearer the large cities have been unable to produce milk in competition with more remote districts and have turned to other types of farming. The price received for market milk has induced many creamery patrons to change their form of marketing for the sake of what appeared to be greater returns. Although the immediate cash receipts are greater for market milk, it is questionable if in many localities the real profits are as great as when the skim-milk is kept to feed dairy calves and pigs. The far-reaching result has been to decrease the number of dairy cattle in New England, although the consumption of milk has actually increased.

Other Lines

Tobacco and onions. Aside from the dairy business, there are several well-developed types of farming in small areas. One of the most striking is the tobacco and onion growing of the Connecticut Valley. From Brattleboro, Vermont, to Hartford, Connecticut, the valley land is chiefly given up to one or the other of these crops, or both in combination on the same farms. This covers an area more than 80 miles long and from 2 to 10 miles wide, beginning in Vermont and New Hampshire, and crossing Massachusetts and part of Connecticut. The tobacco crop is also grown to a much smaller extent in the Housatonic Valley in western Connecticut. Tobacco and onions have been yielding exceedingly good returns per acre, as the soils of the section are particularly suited to both these crops. Land adapted to either of these crops is held at from $200 to $400 per acre, or much higher where the tobacco is shade-grown.

Potatoes. A second special type of farming is the potato-farming of Aroostook County in Maine. The section chiefly devoted to this crop is about 100 miles long and 20 to 30 wide, along the eastern boundary of Maine. The same cropping system has been introduced at various points farther south and west in the state, but not extensively. Potatoes are the principal cash product, and occupy about one-third of the crop land, grown in rotation with oats and hay. Some of the other two crops are sold, as there is a surplus beyond the feed required for the work animals and such other small amount of livestock as are kept. The plowing under of a good sod, usually containing much clover, favored by the cool climate with rare droughts, has for years kept up the humus supply and resulted in good yields. This one area in Aroostook County produces nearly two thirds of the potato crop of the state and makes the average yield per acre for the state higher than elsewhere in the United States, although it does not normally give the state the lead in total production of potatoes although this was the condition in 1916. Not only are the climate and soil favorable to this rotation, but the short cool summer is not suited to many other crops. Corn is practically out of the question, and, although the grazing conditions are excellent, a very long winter feeding season is not encouraging to intensive livestock farming of any kind. Good draught horses and some sheep are raised as sidelines.

FIG. 100. Aroostook County in Maine is one of the leading potato sections in the world

Fruit and truck crops. All through the southern portion of New England and along the coast, more especially within marketing distance of the cities or shore resorts, the fruit and truck industry has become important. This is not a business which can be followed on any large number of farms, because these crops form such a small per cent of our total food supply. However, the early soils of southern New England and the favorable growing season encourage this type of farming.

Poultry raising for eggs and meat has been a profitable business for numerous farmers in southern New England, and has not become localized in any small area, except for the growing of "soft roasters" in eastern Massachusetts a few miles south of Boston. The condition most favorable to poultry raising has been the prevailing high price of eggs in the three southern New England States, where the average value at the farm has been above that in any other section except in a few of the Rocky Mountain States. During the past 5 years the favorable prices have been

FIG. 101. Plain but attractive and substantial houses, with barns and outbuildings attached, and windmills are familiar features of the New England farm country.

to a large extent offset by the increasing cost of purchased grain. This has affected especially the poultryman who kept large flocks on very limited acreage, and to a less degree the man who had acreage enough to give the poultry part of their living by letting them range.

Forestry. The farm woodlands of portions of northern New England offer a special type of farming where men and teams are employed on the general farm crops through the crop season and on the cutting and hauling of logs, lumber, and cord wood through much of the winter. In such localities those farmers who do not have woodland of their own can usually obtain work in nearby woods, or at least send a team to some logging job within 30 or 40 miles, thus relieving the farm of idle horses for the winter. In some respects lumbering furnishes a more economical winter employment than does dairying, since both teams and men are used in the woods, while horses are very lightly used during winter on a dairy farm even if the men are kept fairly busy.

Special Features and Prospects

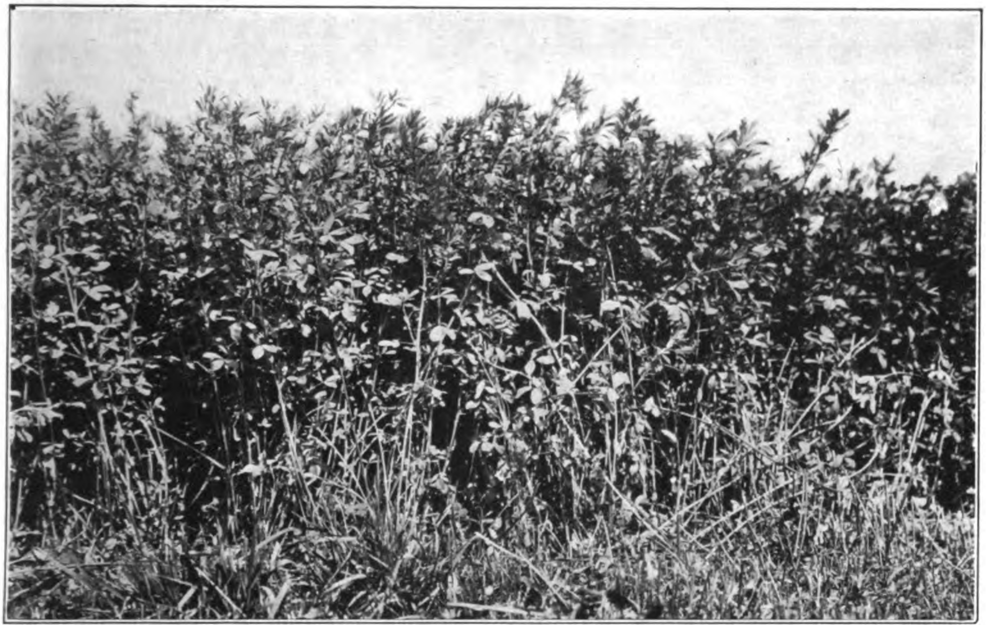
Visitors from other farming regions are likely to be impressed with the substantial character of farm houses and other buildings. In the whole of New England where the farms are at all prosperous, the buildings are as a rule kept well painted and in repair. In northern New England, dwelling house, wood-shed and barns are very frequently connected so that all can be reached under cover in bad weather.

The irregular fields, caused by the uneven surface, are also noted by people from level regions, but as a rule the crop land is selected from the level and more gently sloping land and is not as steep as it is often reputed to be. The steeper slopes are pastured or wooded. In many portions of southern New England the roadside rows of productive apple trees are noticeable to the newcomer. They are planted along the stone walls or other fences and utilize at least part of the space between traveled way and fence, otherwise not profitably occupied.

In much of the hilly country of New England one may be puzzled at the absence of a windmill, hand pump or any sign of a well-curb near the farm buildings. The water supply is often piped to house and barnyard from some hillside spring at a higher level than the farmstead.

One feature of farm life which is conspicuous is the absence in most parts of New England of a good tenant system. Too often the only farms rented are those which have become somewhat run down, and these on a cash basis which allows still further soil exhaustion. The establishment of a custom of share-renting, with restrictions on the part of the owner which would help keep up the condition of the farm, and a share in the expenses for clover seed, and the like, would do much to keep up the productivity and prosperity of those farms which the owner cannot operate. Such a system would also encourage young men who have become dissatisfied with working on a farm for wages to get a start in farming for themselves.

The economic conditions affecting the New England farmer so actutely since the outbreak of the European war, and especially since this country's entry into it, are for the most part merely an exaggeration of the developments which have been under way for several years. The most marked change New England farmers are now (1917) making is toward the growing of more grain crops. The present high cost of grain has convinced the New Englander that he must help himself



The truth about soil acidity is largely a sealed book, even now. But we do know that certain crops require the presence of lime, and that alfalfa is one of them

"When in doubt, apply lime," is a safe maxim for most conditions. The inset shows the yields of mangels from limed and unlimed test plots

LIME IS NOT A FERTILIZER, BUT WITHOUT IT NEITHER FERTILIZERS NOR SOILS CAN DO THEIR BEST

From Earliest Blossom Time until Frost, Cultivation Provides a Means of Conserving Moisture, Destroying Weeds, and Stimulating Crop Growth

by diverting some of his hay acreage to grain—be it corn, oats, wheat, barley, or whatever. The two grain crops most readily grown in New England—corn and oats—are primarily grown to feed stock. Since the milling facilities are poor, it is likely that such other grain crops as may be grown will also be mostly used for stock feed. This may very likely result in fewer dairy cows, but greater relative economy in feeding them. The present high level of milk prices has temporarily checked the consumption of milk. When the public shall have learned more about the relative food value of milk and decides to use it more freely, the supply may be found to be insufficient to meet their demand. It is obvious that those farms which have in the past kept all the dairy cows for which the land could grow all the roughage, will be obliged to reduce the size of the herd in order to grow both roughage and concentrates for it on the same acreage.

Closely following the prices of grain are those of meat, which can more easily be produced from the smaller, quicker-maturing animals. New England can most economically grow that form of meat which uses the largest proportion of pasturage and hay, i. e., mutton. Wherever concentrates can be grown in plentiful supply, and especially where pastures are also scant, pork will be produced. Poultry raising will also develop, but chiefly in combination with other products whereby the birds can consume by-products either in their pens, or by ranging over harvested fields.

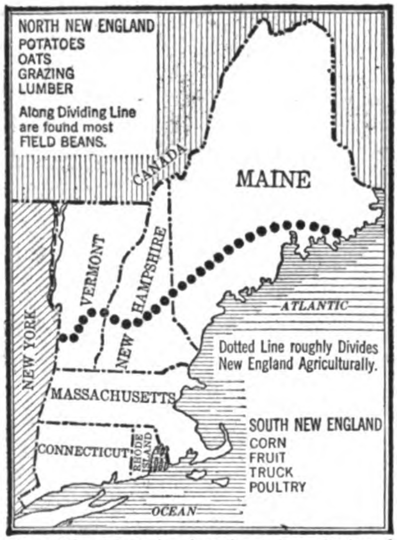


FIG. 102. Map showing the main agricultural divisions of New England

An irregular line crossing New England about through Concord, New Hampshire, divides the region so far as its farming is concerned. In the southern division corn is the most easily grown grain, soil and climate favoring it, while in the northern division oats are more favored by far. Winter rye more naturally accompanies the corn, and spring or winter wheat and barley yield better in the northern section. Along the line of division will be found more field beans than elsewhere. In Southern New England apples are generally favored; in northern New England the potato crop is more at home.

Present conditions are encouraging an increase in the production of field beans as well as of grains, and to a small extent of potatoes and others of the least perishable vegetables which are capable of taking the place, to some extent, of breadstuffs. The supply of vegetable crops can be easily over-produced, so the experienced farmer increases his acreage of any of them with considerable caution. The extensive planting of apple orchards so notable in New England, as elsewhere, is now decreasing, and probably advisedly. The apple market is also one which can easily be over-supplied.

The increase of the New England consuming population is undoubtedly tending to encourage more rather than less farm production. The systems of farming, however, are undergoing a more marked change than has taken place in the last 50 years.

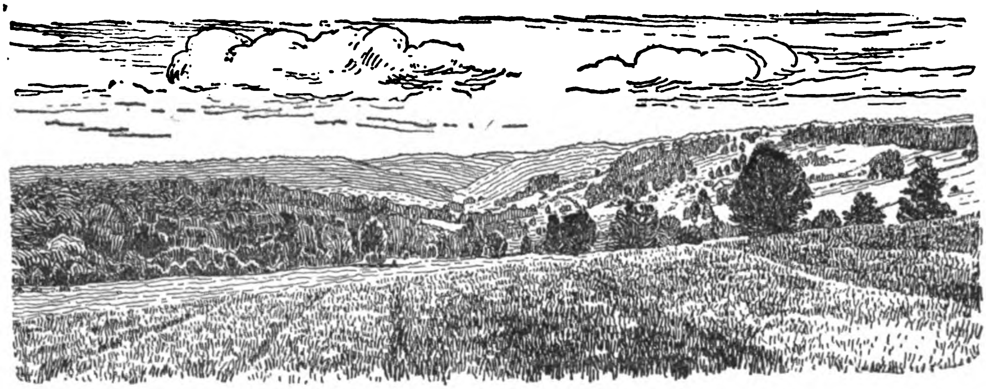


Fig. 103. Typical country north of the glacier line (p. 107) showing the smoothing, valley-filling effect of the movement of the ice sheet. (U. S. Bureau of Soils)

CHAPTER 10

Systems of Farming in the North Atlantic States

By Henry J. Wilder, *Agriculturist, States Relation Service, U. S. Department of Agriculture, who lived on a Connecticut Valley farm in Massachusetts until he entered Harvard University. After graduation he engaged in field work for the Bureau of Soils, at first in the Soil Survey, then investigating the management of soils and their adaptability to different crops. Since 1906 he has owned and operated a dairy and fruit farm in Massachusetts. Although Ohio is mentioned in the chapter on the Corn Belt, on account of its importance as a corn and livestock producing centre, it is also discussed here because of the nature of its soils and surface, and of its close geographical connection with the other North Atlantic States.*—Editor.

THIS group of states includes New York, New Jersey, Pennsylvania, Delaware, Maryland, Ohio, West Virginia, and Kentucky. Covering an area so long north and south and a range of elevation so wide, its climatic and farming conditions vary greatly.

The land surface. A little to the east of the centre of the area lie the Appalachian Mountains, which extend southwesterly from southeastern New York across Pennsylvania, western Maryland, eastern West Virginia and eastern Kentucky. Their general elevation at the north ranges from 1,000 to 2,500 feet, and in the south from 1,500 to 3,000 feet. The rougher parts of these mountain lands are in forest but some of the smoother areas are in pastures, orchards, or in farms. Along the eastern front of the mountains lies the Great Limestone Valley which in Pennsylvania includes the Lehigh, the Lebanon and the Cumberland Valleys, and in Maryland, the Hagerstown Valley. With these large valleys several smaller ones are associated. The continuation of the Hagerstown Valley across the Potomac River in Virginia is the Shenandoah Valley. These main valleys, which have very productive soils, are hemmed in on the east by the narrow Blue Ridge, an outlier of the Appalachian System. Another very important limestone area of Pennsylvania is the Lancaster Valley which lies within the Piedmont Plateau.

Flanking the Blue Ridge on the east is the broad rolling Piedmont Plateau, an important farming area which, with easterly slope and a general elevation of 100 to 500 feet in Pennsylvania and Maryland, extends to the falls line on the rivers, namely at Trenton on the Delaware, Philadelphia on the Schuylkill, Baltimore on an arm of Chesapeake Bay, and Washington on the Potomac. From this line to the ocean lies the Atlantic Coastal Plain, with elevations from sea-level to about 200 feet.

Flanking the Appalachian Mountains on the west is the broad Allegheny Plateau

which slopes to lakes Erie and Ontario, and the Ohio River. The eastern part of this plateau, including western and north central Pennsylvania, West Virginia, southeast Ohio and eastern Kentucky, is for the most part deeply cut with streams, along which the slopes are steep. Where the deeply-cut streams are not near together, the uplands between them are relatively smooth and include broad areas of farm lands, but where such streams are near together, steep ridges usually occur. These steep areas are mostly in forest, but many of the smoother hills are in pasture.

Central Kentucky is a rolling area of limestone valleys and uplands with general elevation of 500 to 1,000 feet. Beginning just north of the Ohio River, this limestone has been overspread with glacial soils, as have all the topographic divisions previously mentioned at the north. This glacial line as shown on the map, extends approximately from Maysville, Ohio, through Newark and Canton to Newcastle, Pennsylvania; Olean, New York; Williamsport and Wilkesbarre, Pennsylvania; to New York City. North of this line the mountains are less sharp than to the south of it, having been rounded off by glacial action which also left a spread of surface soils over this whole region, including New York, the northeast and northwest parts of Pennsylvania and all of Ohio except the southeast part. In Ohio the topography of these soils is gently rolling, as their surface descends in the north to the shores of Lake Erie, while in west central Ohio prairie conditions occur. In New York and in Pennsylvania the topography of this section is gently, moderately or steeply rolling.

Along the New York-Pennsylvania boundary, and in the Catskill and Adirondack regions, the elevations are about 1,500 to 2,000 feet. From these heights to Lake Erie with an elevation of 573 feet, Lake Ontario 246 feet, and its outlet, the St. Lawrence River, extends a sloping, moderately rolling plateau of good farming land. It is on the heavier types of these glacial soils that artificial drainage is not infrequently desirable; in some cases it has already been installed with profit.

Climate. In northern New York the summers are short and the winters long and cold, temperatures of 20 degrees below zero being not uncommon. In the highland area of southern New York and northern Pennsylvania similar conditions prevail. Little corn for husking is grown, most of it being put into silos. Under these seasonal conditions, however, oats and barley do well on the heavy soils. In the fruit belt along Lake Ontario and in the Hudson Valley the winters are more mild, the growing season longer than in the rest of New York, and much more corn is matured.

The growing season of Long Island, northern New Jersey, the southern two thirds of Pennsylvania, and central Ohio is materially longer even than that of the Hudson Valley. Good-sized varieties of corn readily mature, and field operations may be begun earlier in the spring and continued later in the fall. Oats are not as good as farther north but wheat is correspondingly better, except in north central Ohio where the yield per acre is highest in the State, though the yield per county does not surpass that of the southwest section. Corn is a heavy crop in all the western half of Ohio except in the extreme north and south.

In southern New Jersey, Delaware, Maryland, West Virginia, southern Ohio and Kentucky, the open season is longer and the snowfall markedly less. On the heavy soils corn and wheat are good crops, and the length of season permits sowing winter wheat on the corn fields after harvest, thus allowing a 3-year rotation of corn, wheat, clover. This is important, as oats yield less than farther north where there is less hot weather, the dividing line corresponding approximately to the fortieth parallel, which runs through Philadelphia, Pennsylvania, and Columbus, Ohio.

The combination near the seashore of a climate milder than farther inland, and sandy soils which not only dry out early in the spring but are relatively unprofitable for producing general farm crops, has stimulated the growing of early garden produce for markets nearby or farther north. This applies to Long Island, New Jersey, Delaware, and Maryland along "the eastern shore" (of Chesapeake Bay) and southern Maryland (the western shore of Chesapeake Bay).

Population. In all this region the farm inhabitants are predominatingly of English descent, but in certain localities they are now, or in the past have been, exceeded in number by people of other nationalities. The Hudson Valley, for example, was settled largely by the Holland Dutch, and their descendants still are prominent in its affairs.

To Pennsylvania, owing to the broad-mindedness of William Penn, colonists from various European States were attracted. The limestone valleys were largely settled and are still occupied by the Pennsylvania Germans. On the higher lands many Scotch-Irish once settled. In Delaware were colonies of Swedes. The settlers west of the Allegheny Mountains came from the various peoples already mentioned, and from New England and Virginia. Northeast Ohio was the "Western Reserve" of Connecticut and was largely settled by New England people who eventually spread westward to the Indiana line. In southeast Ohio was a French settlement, and in the east central part some Moravians located. Virginians settled south central Ohio and also much of West Virginia and Kentucky.

In addition to these early settlers the businesses of mining, various industries, and

manufacturing enterprises have attracted in recent years large numbers of other immigrants. The coal fields of Pennsylvania, Ohio, and West Virginia include great numbers of Scandinavians, Poles, Lithuanians, etc. So do the great steel industries, which are not far from the soft-coal fields of southwest Pennsylvania and eastern Ohio, and the hard-coal fields of the Scranton district in northeast Pennsylvania; also the manufacturing enterprises of central and southern New York.

In some of the intensive cropping districts, too, where a large amount of hand labor is required, farmers of English descent have not been able or willing to compete with these newcomers. In the onion districts located on the muck soils of Orange, Madison and other counties in New York, and in Hardin, Medina and other counties in Ohio, Poles and Italians have taken a leading part, first as laborers, then as renters, and eventually in some districts as land owners.

Industries and manufactures. The steel centres of the world are in Pennsylvania. One is in the "Pittsburg District," which may be said to include a half dozen or more counties where extensive beds of soft and coking coals are found, and the other at South Bethlehem, which is just south of the anthracite coal fields. All sorts of allied industries have naturally been developed in both districts, and farther out around accessible towns. Extending through Pennsylvania is some of the most efficient railroad development in the world, and located along its main lines is one industrial plant after another. In the eastern part of the State, along the north side of the Great Limestone Valley, cement manufacture is an important industry, and in the western part of the State petroleum oil is a great natural resource. In the northwest, lumber and tan bark have been important industries, as has the former in western Maryland and West Virginia. The coal industry extends from Pennsylvania into western Maryland and West Virginia but industrial manufacturing is not as highly developed there. Ohio also has some coal, important oil fields, and many industrial and manufacturing towns.

Soils and Farm Management

Along the southern shores of lakes Erie and Ontario, lies a belt of lake plain, occupied by the Dunkirk soils, which include more or less limestone. This area not only is relatively free from frosts but has steadiness of temperature as well, and in places, where the soils are favorable, orcharding and the growing of small fruits have been extensively developed. This has been done largely by farmers of English descent, but in recent years incomers from Europe, particularly from the southern part, have also engaged in this industry. Topography made this lake plain the natural place for locating railways

FIG. 104. Hay fields are small as compared with those of the West, but often highly productive

north of the Alleghany Mountains to connect the Middle Western states with New York and New England, hence it is easily accessible to their great markets. In this belt, at the southwest corner of New York, is located the Chautauqua Grape Belt, and nearby is Northeast, Pennsylvania, the greatest grape-shipping point in the world.

Where the fruit business is highly developed on these Dunkirk soils the land has become high in price, and little livestock is kept; but in the eastern extension of these soils from Oswego, New York, to Syracuse and Utica, also along the St. Lawrence River, where fruit growing or other special crop is not developed, dairying and purebred cattle are of first importance. This is due, in part at least, to the productiveness of these soils, and their adaptability to silage corn and the legumes—alfalfa and clover being extensively grown; and in part to the price of market milk which makes it possible to dispose of these crops more profitably through dairy animals, buying additional concentrated feeds from the Middle West and the South, than through beef animals for which mature corn would have to be purchased. The price of land is steadily increasing with the development of the present types of farming.

The glacial soils area varies in its character and development. In western Ohio north of a line from Chillicothe to Hamilton, the glaciated limestone soils are classified as the Miami series and constitute the eastern extremity of the highly productive "corn belt" of the North Central and Mississippi Valley States. The surface is gently to moderately rolling. Corn, oats, wheat, and clover is the principal rotation, though corn is often grown more than one year in succession, and the acreage of oats is less than wheat, as corn and wheat are the money crops. Some alfalfa is also grown. These soils yield a good return on a relatively high valuation.

On the very productive dark-colored Clyde soils of northwest Ohio, corn, oats, and clover is the principal rotation, though some wheat is grown. Cabbage, onions, celery, and sugar beets are also important cash crops. In southwest Ohio the Cincinnati and Clermont soils are less productive silt loams, needing

drainage and organic matter. Corn, wheat, and grass is the common rotation.

In northeast Ohio, in northwest and in northeast Pennsylvania, the soils are grouped as the Wooster, the Trumbull and the Volusia series on the basis of drainage and resulting productivity in the order named. Corn, oats, clover, and grass are the principal crops and these are usually fed to dairy animals. Some wheat is grown. On the better drained areas general farming and dairying are well established and farmers are prosperous. Land is reasonable in price.

In southern New York where the Volusia soils prevail, much drainage is needed, and for the legumes lime also. The season is short, and corn for silage, potatoes, buckwheat, oats, and timothy are the chief crops. Timothy has been used extensively as a cash crop. As milk is the important source of income, and no great amount of grain is produced, the growth of more clover is important. The price of land is low. Potatoes are an excellent money crop for a few, and by practising a short rotation, such as potatoes, oats, clover, and giving proper treatment to the crops, their acreage could well be extended in this section to meet outside competition.

Central New York is a well-developed area of general farming and dairying, while beans, wheat, apples, and onions are cash crops. The soils are good, transportation facilities excellent, and the price of land reasonable. Industrial towns along the New York Central Railroad also furnish local markets. Silos and good farm machinery are common, tractors are coming into use rapidly, and in most of the region a healthful and prosperous farm development prevails. In the short seasons of northern New York, dairying is the primary business, corn for silage, oats, clover and grass the principal rotation, and potatoes an important money crop. The central Hudson Valley is highly specialized in orcharding and small fruits, owing to proximity to New York City, equable climate and favorable soils. Next the river, land prices are high, but nearby there are good opportunities.

On the Alleghany Plateau, and in the Appalachian Mountains area the soils are derived from sandstones and shales and the most important series is the DeKalb. Where some limestone is admixed, the Westmoreland series is found. These are the most productive plateau soils in southwest Pennsylvania, and in eastern Ohio. On them the sheep industry has been prominent, and if dogs were better controlled this business would doubtless expand. On the large areas of DeKalb soils, moderate yields of corn, oats, and grass are secured, and buckwheat is important in the northern part of the Allegheny Plateau. Apples and peaches are extensively grown in some sections, particularly in northeast West Virginia, western Maryland and central Pennsylvania, and in other localities where the western exposure to sleet storms is not too great. Land prices are low except where fruit interests are well developed.

In western Kentucky the principal soils are heavy silt loams of loess formation, hard to handle but productive when well farmed. The leading crops are corn, heavy export tobacco, wheat and grass. Some hemp is produced. In central Kentucky where the soils are largely from limestone and belong in the Hagerstown and Clarksville series, the same crops are grown, but the yields are better. This includes the famous "Bluegrass" section, where much stock is kept and where the farmers are generally prosperous.

The limestone or Hagerstown soils of the Appalachian Valleys and the Piedmont Plateau, are generally considered the strongest soils for general crops in the eastern States. Corn, wheat, clover, and grass in Maryland; and corn, oats, wheat, clover, and grass in Pennsylvania, are the common rotations. Large, steady yields are secured without high expense for fertilization. Wheat is the money crop, most of the corn and oats being fed to stock. Large numbers of steers are fattened, the city of Lancaster being the largest feeder and fat steer market in the East. Tobacco is also an important money crop in Lancaster and York counties. Farmers are prosperous and land prices are high, $150 to $300 an acre. About the same cropping practice obtains on the Chester, or granitic, soils; on the Penn or red sandstone soils; and on the Manor or micaceous soils of the Piedmont Plateau; but their productiveness, the price of land, and the prosperity of the farmers slightly decreases in the order given. Stock keeping is less prominent on the micaceous soils, but garden crops for canneries are of importance in some sections. In Pennsylvania there are many good apple, and some peach orchards on the Chester soils, while on the Penn soils, the order is reversed. At $100 an acre the former offer good opportunities for further development.

The coastal plain region of New Jersey, Delaware, and Maryland includes two very different types of farming. On the heavy soils general farming and late garden crops are the rule, while on the large areas of sandy soils early trucking and small fruits prevail. Near markets the sandy soils are in places highly developed, but away from markets, and everywhere on the more porous, droughty soils, large areas are not consequentially farmed. Such lands are low in price. There are many good soils, however, particularly in the Sassafras series, that are valued at $100 an acre, or more, for general farming purposes and trucking; and considerable areas of similar soils not as well developed afford good opportunities for improvement at $40 to $70 an acre. Corn, wheat, and hay are the principal crops, but dairying, market gardening and canning crops are locally well developed.

Prospects. The rapidly increasing millions of population within a few hundred miles of New York City necessitate an equally steady change and adjustment of surrounding farming conditions to meet the demand for food. Fresh nearby garden stuff commands a premium in price over more distant shipments that makes local production profitable, and this condition will doubtless continue. Market milk has paid in the past where local conditions have been favorable and the methods of farm management effective. But the business has been based largely on feeding homegrown hay with very low average protein content. i. e., timothy and other grasses with far too little clover. This hay has been very properly supplemented by good farmers, with corn silage for succulence, but the protein necessary has been purchased in the form of cotton-seed meal, wheat bran, gluten, etc. As long as these feeds remained cheap the practice was good, but with higher prices for grain it is evident that the amount purchased as dairy feed will have to be decreased, because the modern-day high price of milk has already led to decreased consumption, and the law of supply and demand will have to be readjusted. This applies to the producer as well as to the consumer who is coming to appreciate more fully than formerly the value of milk as a food.

The amount of grain purchased may be decreased in part without lessening milk flow by growing and feeding roughage with a higher average protein content than that grown under the old system when grain was low in price. Of such feeds the most important is clover, but an increased acreage of clover involves a shorter rotation of crops, and consequently the plowing of more land. A rotation of corn, oats or wheat, and clover; or corn, oats, wheat and clover, will not only yield much more roughage protein than when the clover is followed by timothy for one to many years, but it will also maintain a much higher content of humus in the soil and decrease the amount of nitrogen now purchased on many farms, thereby securing a considerable measure of increased soil productivity as a by-product. Such practice is already common in the better local farming districts. Other legumes, as soy beans in the north and cowpeas in the south grown for hay or with corn for silage, alfalfa, winter vetch, etc., all have places of more or less importance in the stock-keeping sections.

The production of the special cash crops, tobacco, onions, celery, garden stuff and potatoes, is generally on a very sound basis; and although the very rapid increase of diseased or toxic (poisoned) fields—particularly of tobacco, onions, and celery—may necessitate the practice of crop rotation even with these crops as a practical means of avoiding decreased yields per acre or inferior quality, these lines of business are well established and will doubtless keep pace with the demand for their products.

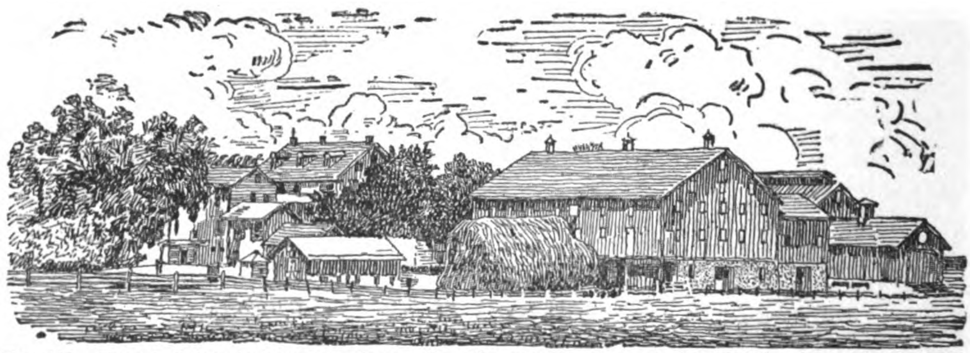


FIG. 105. Farm buildings in Lancaster County, Pa., characteristic of prosperity, good farming and good soils. (U. S. Bureau of Soils)

FIG. 106. A typical corn belt farmstead suggesting a well-balanced farming system involving crops and livestock

CHAPTER 11

Farming Systems in the Corn Belt

By VICTOR H. SCHOFFELMAYER, *formerly Secretary of the Alluvial Land Improvement Association of Tennessee; and* WILLIAM L. NELSON, *for 10 years Assistant Secretary of the Missouri State Board of Agriculture, then with the Extension Department of the University of Missouri, and now U. S. Congressman; a man whose life and work have given him a clear, first-hand, unbiased knowledge of conditions and practices in the Middle West.*—EDITOR.

THE Corn Belt is made up, in the main, of Illinois, Indiana, Missouri, Iowa, Nebraska, and Kansas, although much corn is grown in other states as well. (Ohio, though often included because of its importance in both corn and meat production is, in this book, discussed as one of the North Atlantic States [Chapter 10], to which it seems to belong on the basis of location, type of country, economic development and other features.) It occupies the southern part of the glacial drift area of the upper Mississippi Plains and is largely a gently rolling, fertile prairie broken by numerous rivers but almost wholly free from waste land. It averages 300 to 400 feet above sea level along its southern border, rising generally northward and westward until it reaches elevations of 4,200 feet in western Kansas and 5,000 in western Nebraska. In the southwest the Ozark Mountain country, beginning in central Missouri, presents a more rolling surface that gradually becomes hilly and broken, reaching heights of 1,300 to 1,700 feet. The average elevation of the whole territory is from 900 to 1,000 feet.

A large part of the Mississippi-Missouri River system flows through the Corn Belt or drains it. Here are the Ohio, the Wabash, the Illinois, the Des Moines, the Kansas, and other great streams in addition to the two main water courses; and nearly all of these play important parts in the agriculture of the region. It is along the rivers that most of the woodland of the Corn Belt is distributed, except where fruit and forest trees have been planted as windbreaks, ornamental features, or sources of income. Along the valleys of the Mississippi and Missouri are extensive areas of low, level land frequently flooded in the past, but, when tillable, wonderfully fertile. Extensive reclamation work is going on here including diking, dredging, draining, and the development of these lands. Thousands of acres are thus being added permanently to the productive area of the region.

Of all the rivers included in this group of states only the Mississippi and Missouri are commercially navigable.

Climate is an important factor in this region's famed adaptability to corn growing. The summers are fairly long, warm, and over much of the section, marked by high humidity. Temperatures of 105 or 110 degrees have been recorded in Kansas, but these are not frequent over most of the belt. and rarely continue for long periods. In general the climate is pleasant and healthful. The average temperature for the year ranges from 43 in Iowa to 57 in Missouri. The frost-free season ranges from May 1 to October 1 in the northern part and from April 15 to October 15 in the southern.

FIG. 107. Next to the growing of corn, the fattening of cattle is the foundation stone of Corn Belt farming

Except in western Kansas and Nebraska, rainfall of 30 to 50 inches per year, well distributed over the growing season, is ample for most crops grown in the region. In central Kansas and Nebraska, the precipitation is rather scanty for corn, and farther west, where it decreases to 10 or 20 inches per year, farming necessarily resembles that of the Mountain States (Chapter 15) rather than that of the rest of the Corn Belt. This lack of water increases steadily as the foothills of the Rocky Mountains are approached.

Soils. The soil is almost without exception deep, dark-colored, mellow, and naturally fertile. In the semi-arid sections it is highly productive as soon as water is supplied. Because of its original richness, it has in some places been robbed and brought into rather poor condition; but under careful management even these abused areas can be brought back. Along the rivers, especially the Missouri, and in places extending back for some miles is a great extent of loose or fine, wind-collected soil. This type, found in but few places in the world, is exceptionally deep, rich and responsive. Practically all farm crops do well on it, while for fruit it is unexcelled. The Ozark foothills section of Missouri contains extensive areas of natural limestone soils, well watered and especially adapted to livestock farming.

The people. Although the Corn Belt is probably the most important farm section of the country, its population of about 16½ millions is almost equally divided on the basis of urban (city) and rural (country) location. This is due largely to the fact that Chicago, St. Louis, Kansas City and other large centres are included within its borders.

Most of the states have a large foreign population mostly Germans, Swedes, Norwegians, Russians, Irish, and English. The Germans easily outnumber the others; many who were once farm hands now own highly improved farms. Early settlers in Missouri came from Virginia, Kentucky, and Tennessee, and Indiana was likewise settled largely by pioneers from the eastern, including the New England States. In Kansas are settlements of a religious sect called Mennonites which, coming originally from Russia, brought with them the now famous Turkey Red wheat.

The people of all the Corn Belt are of a high order of intelligence. Schools and churches are liberally supported, and the state agricultural colleges are among the best in the nation. Roads are rapidly being hard surfaced, largely to meet the needs of the many automobiles owned in and driven through the region. Many of the remaining dirt roads are still bad in late winter and early spring, except where the split-log drag is in general use.

Commerce. The Corn Belt is fairly well equipped with transportation facilities, the railroads supplying most of the east and west traffic and the rivers handling much of the north and south tonnage. All the trunk lines from the Atlantic Coast stop in or pass through Illinois and Indiana; and some of the largest of the western lines connect with them at Chicago or St. Louis. Electric lines are extensively developed in some sections, and the Great Lakes furnish an additional outlet from the northern part of the belt.

The great and rapid growth of many of the Corn Belt cities has been the result of agricultural development and prosperity. Grain milling is an immense industry in Chicago, St. Louis, and Kansas City. The packing plants of these cities and of Omaha and St. Joseph killed in 1916 nearly 5½ million cattle, 35 million hogs and more than 9 million sheep, or about five sixths of the total production of the United States.

Other important industries are the manufacture of boots and shoes, agricultural machinery, iron and steel, automobiles, clothing, saddles, and wholesale dry goods; printing and publishing are well represented. The southwestern counties of Missouri lead the country in zinc production, while the southeast section of the belt leads in lead mining. Immense iron deposits are being worked in the St. Francis Mountains of southeastern Missouri. Natural gas is a cheap fuel in southeastern Kansas.

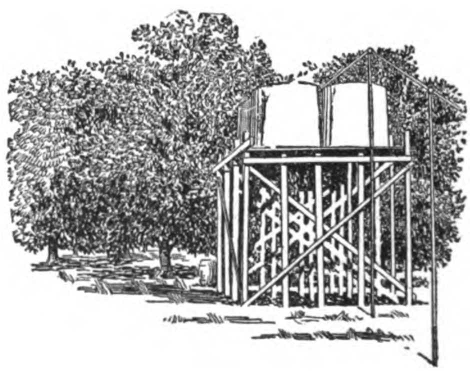


FIG. 108. A spray-mixing plant in a large, progressive Ozark section orchard

Agriculture. It is in the Corn Belt with its well-kept and practical farms that agriculture has assumed its greatest national importance. Here diversified farming with both grain and livestock as important factors is the rule; as a general thing the people, farming with a view to permanency, are prosperous. Nowhere are there more productive, better improved or more intelligently tilled farms than in the Corn Belt, especially its longer-settled eastern and central parts. But even in the more recently developed sections in the level, semi-arid West and the broken, newly-cleared Ozark region of the Southwest, the cabins of the settlers are giving way to comfortable farmhouses surrounded by orchards, vineyards, well-tilled fields and productive pasture land. The oxcart and "prairie schooner" have given way to the automobile, and the countless, far-ranging bison have been replaced by sleek, well-fed, well-sheltered herds of Hereford, Shorthorn, and other beef breeds. Instead of the sod plow breaking tough prairie grass, there is found the tractor-drawn two-, four- or more gang plow, turning under thick crops of clover and other green manures; instead of the one-horse "double-shovel" cultivator, there is the 2-row riding type; instead of wild prairie hay, there are countless acres of corn, oats, wheat, rye, tame hays, and other improved staples. Even cotton finds a small place in the rich reclaimed lands of southeastern Missouri.

Everywhere the Corn Belt farmer is seeking more efficient methods and making larger use of labor-saving machinery. One reason for this is the scarcity of farm help. In Missouri for instance and especially in the river counties, Negro help was once plentiful, but even here the problem is now serious. The supply of European labor, both men and women, that played so important a part in the development of the section is failing also. This shortage is having a decided effect on farming operations. Many men have turned to grass farming.

Livestock. Gradually, however, there is being worked out a system planned to give men and teams year-round employment, and to prevent undue crowding at planting or harvest time. In this system as well as in the marketing scheme of the Corn Belt the importance of livestock is very great. The typically intelligent farmer of this region long ago discovered that the most profitable method by far of marketing his corn, alfalfa and other feed crops was to turn them into beef and pork. On their part the animals in providing manure to be combined with a carefully worked out rotation, have proved themselves the best possible means of maintaining the fertility of the soils. While dairying has reached a high state of development in favored locations within easy reach of the larger towns and cities, beef raising is typical of practically all parts of the Corn Belt. This section stands as the natural centre of the country's beef production; while it is claimed to possess one-third of the cattle of the United States other than milch cows, it is probable that all things considered the 7 Corn Belt states represent fully one half of the beef-producing industry of the nation. Inseparably associated with the cattle and the corn that fattens them is found the typical American hog. The Corn Belt, well known as the "Nation's bread basket" is no less its greatest beef and pork market. In Missouri, the Corn Belt can claim one of the nation's centres of saddle-horse and mule production, while farther north are found probably the best and the largest number of heavy draft horse breeding establishments in the country. Sheep have not always been thought of as typical Corn Belt animals, but with the price of both meats and wool justifying a heavier investment in buildings and feed, they are gradually making (if not finding ready made) a permanent place in feed lot and on pastures. With such extensive livestock interests it is not surprising to find a keen appreciation of quality in the Corn Belt farmers. Hundreds of the herds are entirely of purebreds; many more are headed by registered sires of good breeding and worth. Thus it is to this section that the West and South have looked and continue to look for their foundation stock. Important factors in arousing and holding an interest in good animals are the large and successful State Fairs and the internationally known livestock Expositions, such as the International at Chicago, the American Royal at Kansas City and others. And of course the admirable facilities for marketing with their

FIG. 109. Hogs, either as a specialty, or in combination with cattle, are a vital factor in the Corn Belt

premiums for type and quality products, offer an additional inducement.

Crops. In speaking of its livestock interests first, we must still realize that its crops make up a tremendous foundation on which the fame and achievements of the Corn Belt rest. The state's statistics given in Volume IV measure the actual production of corn, wheat, oats, and the rest. The soil is at the bottom of these results, of course, but the climate has helped; and careful selecting, testing and cultivating on the part of the farmers have done their share. The introduction of hard-wheat varieties well adapted to Western conditions has had much to do with the big wheat yields of Kansas and Nebraska; the first of these states cuts more alfalfa each year than any other; Missouri is said to lead the nation in acreage of bluegrass; and timothy, clover and prairie hay contribute generously to the wealth of the region.

Where rainfall is uncertain irrigation is practised to some extent, but the yields of the semi-arid plains are more the result of choice and development of drought-resisting crops. The sorghums do especially well here. The river valleys produce a large white potato crop each year as one phase of a rotation which includes corn, grain and cowpeas, clover or some other legume. Truck crops are less important than in regions of more specialized agriculture, although largely raised near the cities. Of the fruits, apples are the most generally grown, but peaches and berries reach commercial proportions in the Ozark section. Because farming in the Corn Belt is generally done on a fairly large scale, its per-acre yields of many of these crops are excelled in other states where smaller areas are given more intensive care. But in magnitude of production and therefore in importance as a source of food products, the Corn Belt is outdone by no section in the world.

On the soils that have been longest under cultivation, as in the eastern part of the belt, commercial fertilizers, especially phosphoric acid, are being applied with good results. Elsewhere they are not used to any great extent, nor are they generally needed. Increasing use is being made of extensive deposits of limestone, and large quantities of the rock are being quarried, often by the farmers themselves, and ground and hauled direct to the farms. This practice is having its effect especially in increasing the acreage and yields of clovers, alfalfa, etc.

Progress and developments. Improved farm machinery, including tractors, is used as well as made within the Corn Belt. The increased power makes possible deeper plowing, and a deeper seedbed, the cultivation of larger areas per unit of man labor, and generally a lower cost of production per acre. Silos have become practically an essential feature of Corn Belt farming and have been erected all over the section. On the semi-arid plains the pit silo is successfully used. (See Volume III.)

Hand in hand with the campaign for better and more profitable farms is going a broad movement for more attractive, more homelike homes. This, and the awakening of the public mind to the needs of the farm woman along lines of improved labor-saving machinery, promise to keep the Corn Belt in its enviable and responsible position in agricultural America.

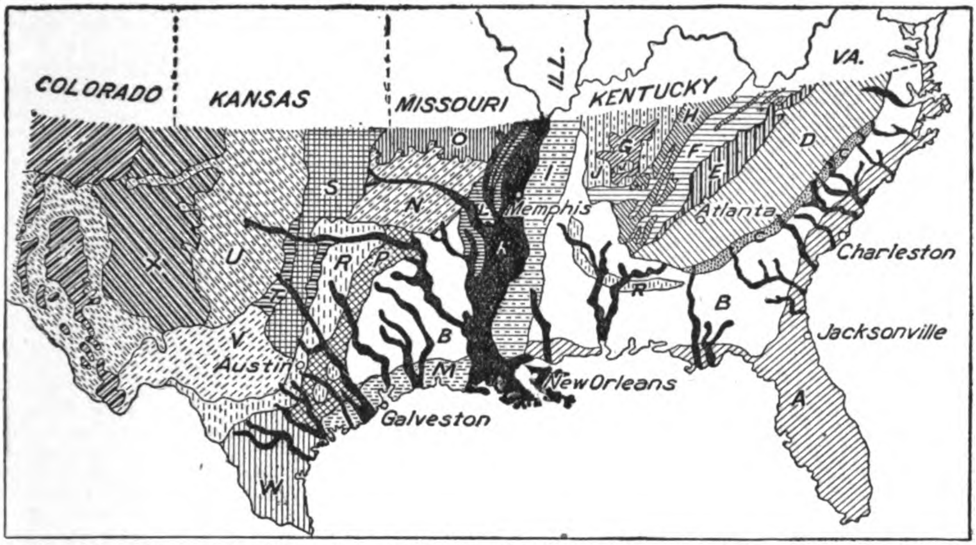


FIG. 110. Soil map of the Cotton Belt. A Atlantic and Gulf flatwoods, mainly light-colored sands and dark, poorly-drained soils; B Interior Atlantic and Gulf coastal plains; C Sand hills; D Piedmont plateau; I Loessial region, silt and loam; K River flood plains; L Silty terrace lands; M Coastal prairie, low flatland, marshy near coast; N Ozark and Ouachita Mountains; P Coastal Plain; R Black prairie, calcareous black-waxy lands; S Black prairie, sandstone, shale and limestone; U Red prairie, sandstone, and shale soils; V Edwards and Stockton plateaus; W Rio Grande plain; X Staked plain. (Farmers' Bulletin 802).

CHAPTER 12

Farming Systems in the Cotton Belt

By VICTOR H. SCHOFFELMAYER *(see Chapter* 11) *Field Editor, Texas semi-weekly "Farm News" and previously, for 3 years, editor of "The Southwest Trail." His activities as a writer and lecturer on agricultural subjects have taken him over most of the United States, in all parts of which he has made a special study of farming systems and conditions.*—EDITOR.

GENERAL description. The Cotton Belt occupies the southeastern part of the United States and comprises Virginia, North and South Carolina, Georgia, Tennessee, Arkansas, Oklahoma, the northern part of Alabama, Mississippi, Florida, Louisiana, and Texas. Broadly treated, this territory embraces (a) the Atlantic and Gulf Coastal Plains, with an elevation ranging from sea level to 600 feet; (b) the Piedmont Plateau, 300 to 1,500 feet; (c) the Appalachian and Ozark Highlands, 1,500 to more than 6,000 feet; (d) the Mississippi River Flood Plain or Delta, 100 to 300 feet; and (e) the Western Prairies, rising 1,000 to 5,000 feet.

Forests of southern or yellow pine formerly occupied the coastal plains and the plateau and highland regions. Much of this timber has been cut, but extensive areas still remain. The hardwood belt extends through the Delta and the Upper Appalachian region.

The Delta lands are of alluvial (river-formed) origin, having been deposited throughout the ages by the Mississippi River as it brought down with it fertile soil from 26 northern states through which it runs. Large areas have been artificially drained giving rise to what are considered among the most productive soils in the world. Natural drainage exists. In some localities conditions make

for natural drainage. A system of levees to protect the low-lying lands from overflow is to be maintained by the Federal Government.

There is much broken land in the hill sections of each of the Cotton Belt states. Parts of Oklahoma, Northern Texas, Arkansas, and the Appalachian Mountain districts offer no agricultural advantages, but are valuable grazing areas.

Soils. The soils of the coastal plains vary from sandy marls and marsh lands of great fertility, when drained, to fertile loams and sandy clay. The plateau soils are mainly heavy red clay and gray sandy loam with occasional soils of limestone origin. The black prairie soils of Alabama and parts of Mississippi and Texas are of highest fertility. The loess (wind-formed) soils along the Mississippi River have lost much fertility through leaching. The prairie soils of Oklahoma and Texas are productive provided they receive sufficient moisture. Practically all river valleys have alluvial soils which are productive.

Climate. The climate of the Cotton States is warm and moist. The frost-free period for the southern sections of the region is about 240 days and for the northern portion about 210 days, or from April 1 to Nov. 1. The average annual temperature varies from 55 to 60 degrees F., extreme temperatures ranging from 100 or more degrees F. to below zero. Cold waves never remain long, but often do considerable damage.

The annual rainfall through the coastal plains and the Appalachian highlands and the lower Mississippi Valley averages 50 to 60 inches. Extremes of 70 inches fall in southern Alabama, Mississippi and upper Florida. Throughout the upper parts of Alabama, Mississippi, and western Tennessee, Arkansas and southern Oklahoma the precipitation is 40 to 50 inches annually but westward on the Plains it decreases to 20 to 30 inches.

Population and development. The Cotton States were among the first to be settled. French and Spanish colonies were established along the Atlantic and Gulf coasts and a brilliant civilization was established some 300 years ago. Cities, which then were mere outposts, rank to-day among the most important and wealthy of the nation. Descendants of the pioneers in many cases have remained to inherit the lands and position of their ancestors and many districts in Louisiana, Florida, Mississippi and Alabama have a large population of south European origin. The Southern farming system makes for communities, hence the agricultural population often centres around the small towns. In the Old South, the type of inhabitants is distinctly Southern, and clings in a measure to old-time customs and business methods. However, the introduction of new blood and new, progressive ideas has had marked results in the more northerly territory. The mountain population tends to be backward in development, largely because of lack of means of communication as well as restricted opportunities for farm development. But the mountaineers are a hardy race, descended in part from Virginia stock and having recently developed increased interest in efforts being made to better their conditions.

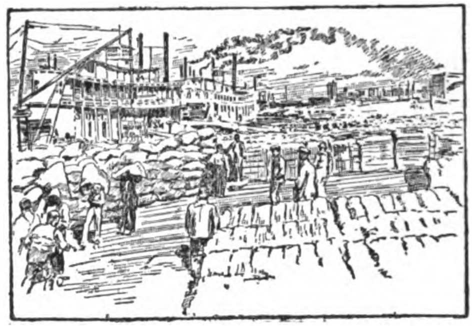


FIG. 111. Levee scene on the Mississippi River

Industries and commerce. Among the leading industries of the Cotton Belt are lumbering, cotton manufacture, sugar refining, steel milling, coal and iron mining, packing plants, oil mills, textile and tobacco factories, flour mills, livestock feed mills, tanneries, fertilizer plants, breweries and shipbuilding. Turpentine and resin are important by-products of the lumber industry. There are hundreds of saw mills, planing mills, cooperage and box works and factories for the manufacture of creosote, methyl alcohol, charcoal, potash, acetone and other chemicals. In 1916 the oil yield from 4,600,000 tons of cotton seed totaled 184,000,000 gallons, valued at $200,000,000. The oil mills are now accepting also soy beans, Spanish peanuts and velvet beans for crushing.

Railroad facilities and water transportation are being increased to keep pace with the growth of industry. Important trunk lines originate in the Cotton States and connect with the northern, eastern and western lines. Coastal shipping lines take truck crops and other farm products into such cities as New York, Boston and Baltimore. Steamer traffic on the Mississippi is feasible as far north as St. Louis. Important transatlantic southern ports are New Orleans, Galveston, Mobile, Jacksonville, Gulfport and Biloxi. The chief markets are, besides the above, Atlanta, Memphis, Houston, Savannah, Birmingham, Norfolk, Oklahoma City, Little Rock, Nashville, Tampa, Raleigh, Dallas, Fort Worth, San Antonio, Muskogee, Montgomery, Pensacola, Charleston, Chattanooga, Vicksburg, and Baton Rouge.

The Agriculture of the Cotton Belt

The Cotton States naturally are an agricultural region. They have a favored climate for great diversity of crop production, a long growing season, varied and responsive soils and an abundance of moisture.

Cotton. Up to recent times the farming system of the entire South centred around cotton, which, as a result of an unusual combination of climate, soil, markets, and labor conditions, has been the great staple for centuries. The annual yield of cotton varies from an average of 10,000,000 bales to 16,000,000, as in 1914, with accompanying variations in price from 6 to 12 or more cents a pound. The South's total farm crops for 1916 were valued at $3,004,169,000 of which cotton represented $1,357,000,000.

Modern methods. There is scarcely an acre of drained land in the Cotton States where cotton will not mature a crop. It is this fact which has made cotton king of all Southern crops. While long-staple varieties are grown only on the most fertile and highly cultivated soils, even the hill farmer with his cotton mule will raise a fourth of a bale of short fibre to an acre. There are cotton plantations where 2 bales an acre are produced regularly; but there are also regions where the boll weevil has made the raising of the crop ruinous. The constantly increasing injuries from this cause and the increasing evils of a one-crop system made themselves felt to such an extent that whole districts were compelled to abandon cotton and turn to a rotation of other crops. This new, diversified agriculture is the foundation upon which the future success of the Cotton Belt must rest. Legumes, such as the various clovers and alfalfa, Spanish peanuts, cow peas and velvet beans now occupy a regular place in practically every crop rotation and play an important part in maintaining soil fertility. Five million acres of velvet and soy beans were grown in the Cotton States in 1917.

It was in 1902 that Dr. Seaman A. Knapp of the United States Department of Agriculture began his work of combatting the boll weevil and instituting crop rotations. His fundamental doctrines are: Good seed; a well-prepared seed bed; early planting and frequent shallow cultivation, forcing the cotton to mature its bolls before the advent of the weevil, which lays its eggs in the tender squares. In infested regions it has been found practical to burn all fallen squares. Under Dr. Knapp's guidance the entire farming methods of the South have gradually been changed. Formerly the average farmer did not raise sufficient corn, hay, or other feed for his stock or enough food to supply himself and family; in 1916, the South produced a surplus of diversified crops. Dr. Knapp's founding of Boys' Corn and Pig Clubs, and Girls' Canning and Poultry Clubs has revolutionized agriculture throughout the South. These clubs have accomplished more in a few years than was possible under the old system in a decade.

The most significant feature of Southern agriculture is the opportunity for raising 2 crops in a season on the same land. This naturally results from the long planting and growing seasons. It is the accepted practice to sow cow-peas, soy beans or velvet beans in corn rows at the last cultivation. This crop of vines and beans is generally pastured by stock during the fall, although in many sections the beans are gathered for market.

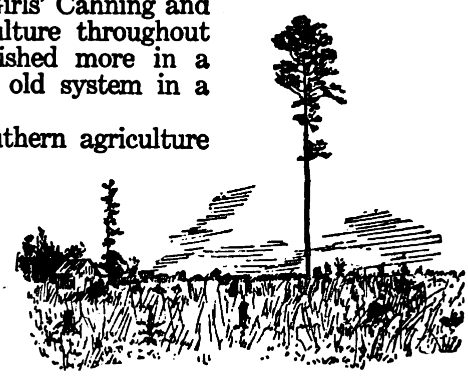


FIG. 112. Cutover pine land as found in Louisiana and other parts of the Cotton Belt

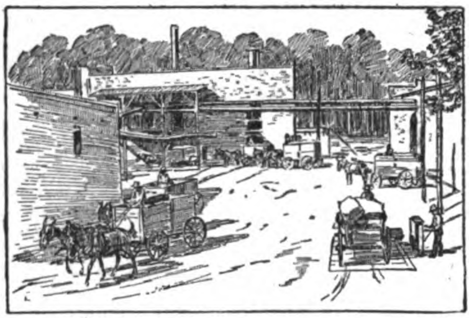


FIG. 113. A modern cotton gin

Cotton-Growing Methods

Under a cotton-growing system it is customary to allot 15 acres to a tenant working one mule and 40 acres to one having a team. Investigations show that the average depth plowed for cotton is slightly more than 4 inches. The highest yields of cotton are made on sandy loams, which permit deeper plowing and work more easily than heavy soils. Fine crops are made in the Delta or alluvial region of the Lower Mississippi Valley, where averages on large plantations vary from 750 to 1,000 pounds of seed cotton an acre. Delta soils need no fertilization but hill lands demand it. Throughout the Delta all farming is done by Negro labor. There is no regular crop rotation, the soils being of such fertility that there are records of continuous cotton production on the same land for almost a century. Occasionally a three-year rotation is followed, in which two years of cotton are succeeded by one year of corn and cowpeas, the cowpea vines being plowed under. In preparing the field for cotton in the Delta regions either plows or listers are used. The latter break up the middles of the rows which first have been turned up by plowing a furrow on each side. Before the cotton is planted the land is bedded and harrowed down with a spike-tooth harrow to a general level of 4 inches. The usual method of planting cotton is with a one-horse planter in rows 4 feet apart, using 3 to 4 pecks of seed per acre. When the plants are 4 or 5 inches high they are "chopped" or hoed and cut down to a stand of about one to every 15 or 18 inches. The most popular tool for cultivation is the 5-shovel cultivator equipped with sweeps instead of plow shovels. Cultivation is necessary every 10 days, a crop receiving from 8 to 14 cultivations. The chief varieties of cotton grown are Trice, Simpkins', Express and Dodds. Grass is very troublesome, as are morning glories, Johnson grass and coffee weed.

The sandy loam soils of the Atlantic coast region compare well with the Delta in production. Most farmers on these soils also depend upon a 1-crop system, although the more progressive plant cowpeas and Spanish peanuts between the corn rows at the last cultivation. A little oats is grown on almost every cotton farm, followed by cowpeas.

The cotton methods of the Piedmont Plateau and border lands do not differ greatly from the general system described above. Fertilizers are extensively used in Florida, Texas, and Oklahoma cotton fields at rates varying from 250 to 300 pounds an acre. There are many mixed varieties of cotton. There is, of course, a wide difference in the yield of cotton on the sandy or clay hills of the Cotton States and the alluvial lands. To increase cotton production in the hills, the following 4-year crop rotation is successfully practised in Mississippi, Louisiana, Alabama and the upland cotton region of the Atlantic coast states:

First year: Corn and cowpeas, followed by oats seeded in September.

Second year: Oats (planted the year before) followed by cowpeas; bur clover and rye after the peas are cut for hay (bur clover and rye make excellent winter pasture).

Third year: Rye and bur clover (planted the year before) are plowed under in April and the field planted to cotton. Bur clover and rye are broadcasted in the cotton after the first picking.

Fourth year: Bur clover and rye (from the year before) are followed by lespedeza sown in February or March and making pasture till November 1. All winter-growing grains and clovers furnish pasture from January 1 to March 15 with good management, and under especially favorable conditions, will yield as large crops as if they had not been pastured. Modifications of the above rotation have been successful in every section of the Cotton Belt.

Livestock

The eradication of the cattle tick in more than half the originally infested area of 741,515 square miles has resulted in untold benefit to the South. According to Government reports the entire infested area will be tick-free in a few years. This will permit a general interchange of northern and southern livestock and will admit southern steers to the great packing centres on equal terms with northern cattle. There are some 17,000,000 cattle of all classes in the Cotton States, of which 5,100,000 are dairy cows. Dairying flourishes especially in the hill districts. The vast cut-over pine land area of Louisiana, Mississippi and adjacent states is the home of hundreds of dairy farmers and the industry is highly developed in Georgia, Tennessee, Virginia, and the Carolinas. There are about 15,000 silos in the dairy sections, one of the most popular styles being a wood-hoop silo, which can be constructed at a cost as low as $1 per ton capacity. Coöperative creameries are in operation in the dairy districts.

Large areas in Louisiana, Mississippi, Tennessee, Texas, and Georgia are devoted to the raising of beef cattle. Throughout much of this region lespedeza, known also as Japan clover, grows wild and forms the basis of exceptionally profitable pastures. A mixture of lespedeza and Bermuda grass helped out with white or crimson clover during the summer and bur clover during the fall, will support from 2 to 3 steers an acre for 4 or 5 months if moisture conditions are right. Experiments show that very cheap beef, pork, and mutton can be produced in the South on the comparatively low-priced hill lands.

Vegetables and Fruit

Truck-growing along the Atlantic Coast from Norfolk, Va., to Florida, has reached large proportions. Hundreds of millions of dollars' worth of vegetables, many grown out of season, are marketed every year in New York, Philadelphia and other Eastern centres. Several very important Irish potato-raising and the main sweet potato regions are located in this Atlantic Coast country. Coastwise shipping and an excellent railway system make possible the prompt disposal of these perishable crops.

As a fruit-producing territory the Cotton States are somewhat limited in area. Apples are grown commercially in Virginia, North Carolina, Georgia, Tennessee, and Arkansas, with a total crop for 1917 of 11,265,000 barrels valued at $35,000,000. Georgia's peach crop is famous, outranking that of Texas and Arkansas. The production of pecan nuts is also assuming important dimensions in certain sections.

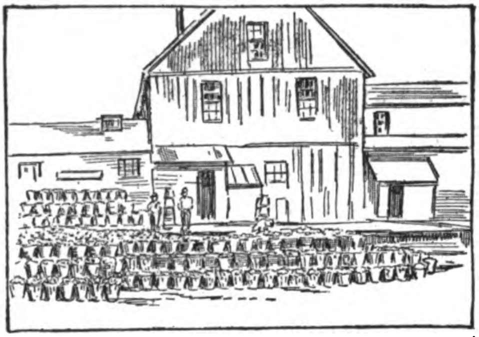


FIG. 114. Canning factory in Maryland, but typical of other parts of the Atlantic Coast truck section

Other crops. Natural conditions in the alluvial region of Arkansas, Mississippi, Tennessee, and Louisiana, are ideal for alfalfa which yields 6 crops a season or an average of 5 to 6 tons an acre. Inoculation is not required in the upper sections of the Delta. Alfalfa has also been grown successfully on the limestone hill soils of Tennessee, Mississippi, and Alabama, and generally grows well wherever sweet clover will, if properly seeded and cared for.

The production of sugar cane for the making of syrup as well as for forage is extensively followed in the Cotton States. Several states are noted as tobacco-producing territories. An ideal combination is tobacco and peanuts, the latter largely keeping up the soil fertility, which is rapidly depleted by the clean-cultural methods used in raising tobacco.

Farm tendencies and the outlook. There are more than 7,000 gasoline tractors on Southern farms, indicating a marked tendency to substitute fewer skilled farm hands and improved machinery for the larger numbers of less-skilled Negro laborers. There has been a movement of Negro labor away from the Cotton Belt during recent years, the higher wages for city work having lured the Negro away from the plantations. His disappearance has been severely felt in certain sections.

In the past, Northern farmers have not flocked to the South, but have rather migrated to the West and Southwest. Of late there has developed considerable movement toward the Cotton States—the result of an appreciation of the opportunities that abound there. Formerly certain districts were shunned as being unhealthful, and with good reason. To-day immense areas of so-called swamp lands have been drained and the breeding places of the malaria-carrying mosquito destroyed; artesian wells are numerous throughout Mississippi, Alabama, and Texas; deep wells have been sunk everywhere and community health has been immensely improved. Agricultural experts believe that the Cotton States not only will always be a leading cotton-producing region of the world but also will become one of the most important sources of the nation's general farm crops. The tendency is entirely toward better and safer farming methods; as an illustration, the cotton acreage was substantially cut down in 1917 to make possible greater production of much-needed food for humans and feed for livestock.

FIG. 115. Truck farming along the gulf is practised on both light, sandy soils as shown here and the rich, black mucks of newly drained swamps.

CHAPTER 13

Farming Systems in the Gulf Coast Section

By VICTOR H. SCHOFFELMAYER. (*See Chapters 11 and 12*). *As author of "The Alluvial Empire," Mr. Schoffelmayer had both need and opportunity to study the conditions and possibilities of this part of the country, where are combined features of the temperate and tropical zones, and where are found some of our most interesting farm activities.*—EDITOR.

THE Gulf Coast Section occupies the low coastal plains region along the Gulf of Mexico in Florida, Mississippi, Alabama, Louisiana, and eastern Texas. It is treated as a separate division because of its closeness to the Gulf, which exerts a powerful local influence upon climate, vegetation, and naturally, farming. The coastal plain is a comparatively narrow, level region averaging 40 to 100 miles in width and varying in elevation from almost sea level to an average altitude of 100 to 150 feet above. The highest point is about 600 feet, being an outrunner of an Appalachian mountain spur.

Land and soils. Practically the whole Gulf Region was originally covered with forests of long-leaf, short-leaf and loblolly pine, cypress, oak, palmetto, and several species of trees and shrubs peculiar to the West Indies. Large areas of fertile muck and peat soils have been drained and put into crops, but there still remain large bodies of unreclaimed lands along the coast in need of drainage. There are large areas of dunes unsuited to farming, and considerable territory is subject to tidal overflow. Some lands are too level to drain naturally.

The soils of the Gulf Coast States are divided into the light sandy lands along the shore and extending inland in places more than 50 miles; the marshy "hammock" lands of high fertility; piny woods—flat lands and low ridges; and alluvial lands following the courses of streams. The sandy soils, apparently unproductive, are made to yield well through scientific treatment. Wherever "hammock" lands are successfully drained the yields are heavy.

Climate. The climate of the Gulf Coast is sub-tropical, the average range of temperature annually being about 66 degrees for the coastal plains proper and about 77 for southern Florida. July temperatures rarely exceed 85 degrees, but the humidity is high. The annual frost-free period averages 290 to 300 days or from Feb. 15 to Dec. 1-15. The last frost in lower Florida generally comes about Feb. 1.

The rainfall averages more than 60 inches a year in northwestern Florida, lower Alabama and Mississippi. The Gulf Coast region of Louisiana and the central parts of Florida

have 50 to 60 inches a year while eastern Texas has a range of 30 to 60 inches, the heaviest precipitation being in the northeast. Rainfall at the mouth of the Mississippi River exceeds 60 inches.

History, people, commerce. The Gulf Coast was populated by early French and Spanish expeditions and boasted a flourishing civilization long before the upper Atlantic Coast was permanently settled. Hundreds of years ago the cities of New Orleans, Mobile, and Pensacola were founded. A large per cent of the present population of these cities and the surrounding rural territory is descended from the founders. French is widely spoken in entire parishes of lower Louisiana, but the Spanish influence has largely disappeared. As in other sections of the South, the rural population is chiefly composed of land owners whose plantations are operated by Negroes. Immediately surrounding the larger cities are communities of Italian and French, Belgian and Alsatian market gardeners. There is a great lack of education among both white and Negro laborers. The important markets and industrial centres of the Gulf Coast States are New Orleans, Mobile, Galveston, Tampa, Tallahassee, Pensacola, Key West, Fort Meyers, Biloxi, Gulfport, Houston, Rockport, Corpus Christi, Brownsville, Lake Charles, and Baton Rouge.

Industry. The principal industries are the production of sugar and syrup from sugar cane, cotton ginning and spinning, the manufacture of livestock feeds, utilizing waste products of the sugar and syrup industry, crushing vegetable oils from cotton seed, soy beans, Spanish peanuts and other legumes, rice milling, tobacco factories, ship building, iron and steel mills, refining of turpentine and resin, lumbering and manufacture of lumber products, fishing and the canning of marine products. All ocean ports have large elevators for storing corn, wheat, kafir and other grains for export. Most industries are dependent, directly or indirectly, upon farming.

FIG. 116. A field of sugar cane showing a combined irrigation and drainage ditch alongside

Railroad facilities are sufficient so far as the principal markets are concerned, but there is need of increased service in the remoter districts. The markets of the Middle West and the great Atlantic seaports are readily reached by railroads or sea routes.

Much of the Gulf States region is still in timber, and thousands of men are employed in harvesting this native crop. Large areas of pine cut-over land have been settled recently and organized effort, in which state and federal authorities are coöperating, is at work colonizing the pine flats and rolling land along the Gulf of Mexico. There is a large influx of northern farmers and livestock raisers.

Farming Activities

The long planting and growing seasons of the Gulf Coast States are responsible for great variety in farming systems. As a rule the usual southern system of one crop has been followed but the work of the county demonstration agents is having its effect upon the farming system.

The territory surrounding the larger cities has attracted settlers who have engaged in truck growing, dairying, beef fattening and in a complicated and scientifically conducted fruit industry.

Livestock production is claiming the attention of many southern planters, who formerly devoted themselves exclusively to cotton or sugar. The profits made from the business are high, due to the high carrying power of pastures and length of the grazing season. Contrary to former general opinion, the black Angus cattle can be as easily grown and fattened along the Gulf Coast as any other, the color not being, as was believed, a disadvantage. Throughout this productive region it is possible to raise silage crops of enormous tonnage to an acre. Japanese seeded ribbon cane, for example, often yields 20 to 40 tons of silage an acre. Corn averages 40 to 75 bushels and the famous long-staple cotton of the alluvial regions produces 1,000 to 1,200 pounds an acre. The yield of sugar cane averages

12 to 20 tons an acre, Louisiana leading in both sugar cane acreage and sugar production. In 1916, it produced 303,900 short tons of sugar, the largest crop since 1911. The yield was 146 pounds of sugar per ton, or a total of 4,172,000 tons of cane, averaging 18 tons an acre. Molasses production averages about 13,000,000 gallons annually or an average yield of 93 gallons per ton of sugar. There are about 150 sugar factories in Louisiana, Eastern Texas and a small area of lower Mississippi that produce 7,000 to 8,000 short tons of sugar every year. There are 12,000,000 acres of cane land in the Gulf region, but less than one fourth is under cultivation at present.

Grains and forage crops. While a large acreage is devoted to general farm crops, such as corn and other cereals, legumes, potatoes and hay crops, the Gulf States region is the premier producer of winter crops of vegetables. These are shipped to the large northern and eastern markets where they command top prices. Eastern Texas and lower Louisiana are famous as early potato-raising territories, the chief varieties produced being Irish Cobbler and Bliss Triumph. Florida winter potatoes reach northern markets in February, following closely upon the Bermuda crop. To prevent the potato from degenerating in such a warm climate, the seed used is regularly imported from Minnesota and Maine, where the potato develops a vigorous type.

Vegetables. The growing of winter truck crops is one of the most profitable activities of the Far South. Thousands of truck-growers have cleared large sums, often harvesting crops which return $200 to $500 an acre under intensive systems of culture. Florida shipped, in 1917, about 50,000 cars of winter and early spring vegetables; eastern Texas shipped 5,000 cars of cabbage, 500 cars of onions, 100 cars of lettuce and 800 cars of mixed vegetables. The Brownsville (Texas) region is famous as a producer of winter onions and other truck crops. The Magic Valley is one of the most productive vegetable districts of Texas, the soils yielding as high as 800 bushels of onions and 12 tons of cabbage per acre. Hidalgo and Cameron counties in the same state shipped, in 1917, 1,789 cars of cabbage, onions, lettuce, and potatoes. Similar crops are grown on the developed coastal lands in Alabama near Mobile and scattered along the bay of that name. Southern Mississippi and the frost-free Keys off the lower Florida coast also are noteworthy as vegetable-producing sections. Texas shipped 7,000 cars of Bermuda onions in 1917.

FIG. 117. Raising corn on partly cleared long-leaf pine land

Fruits. The Gulf Coast States are an important small fruit raising section. More than 8,000,000 crates of strawberries were produced in 1917, the leading state in this line being Louisiana; its pine lands in the lower part of the state are ideal for strawberries. As a producer of watermelons Florida leads with 7,500,000 for 1917 and Texas follows with 5,489,000. Florida, Louisiana, and Alabama also are important shippers of cantaloupes, totaling 400,000 crates. An important industry is the raising of the fig, which grows well throughout the entire Gulf territory. Commercial orchards are paying well. Peaches are raised on the higher ridge lands along the Gulf.

The citrus-fruit industry, most highly developed in Florida, is an important Gulf State development, of comparatively recent origin, but spreading rapidly. Alabama and lower Louisiana are annually increasing their citrus-growing area. Eastern Texas and lower Mississippi also have flourishing orchards. Included under citrus fruits are oranges, lemons, grapefruit (pomeloes), limes, tangerines, mandarins, kumquats and citrons. The bulk of these fruits is grown in Florida, which in 1915-16 shipped 6,050,000 boxes of oranges. As a producer of grapefruit Florida leads the country with 2,000,000 boxes a year. Alabama's strides as a citrus-fruit producer have been rapid. More than 2,000,000 trees are growing on 20,000 acres, the investment representing about $6,000,000. Below Mobile there also is a large pecan-raising territory, with large commercial orchards growing the famous papershell nut of commerce. Oranges also are being grown in this territory with success.

The average size of farms in Louisiana,

Florida, and Alabama is about 90 acres. There is a tendency toward smaller farms as the farmers become more skilled in the growing of special crops. The favorable season enables them to keep the land producing for 9 to 10 months a year. The alluvial soils in the Gulf region are not fertilized, but the hill and sandy lands of the pine flats require much fertilizer. Soil analysis is essential before setting out an orange or grapefruit orchard.

Legumes, yielding enormously, are the chief dependables in the Gulf Coast crops rotation. Velvet beans make such heavy growth that corn with which they are planted is weighted almost to the ground with the vines. The general method of plowing is to throw two furrows to a centre, making a high ridge on which practically every crop is grown. This applies especially to sugar cane, corn, potatoes, and vegetables. Enterprising newcomers, however, have found that ridging is not essential and that flat cultivation is simpler and permits of the use of modern machinery at all times. The ridges are intended to carry off the water or to hold it away from the growing crop. However, where thorough drainage has been provided, flat breaking and planting is established.

Rice. More than 10,000,000 acres, according to an investigation of the Gulf Coast lands, are suited to the raising of rice. In this industry Louisiana and Texas lead. In 1917, the former state yielded a total of 20,392,000 bushels, and Texas 10,575,000 bushels. Rice yields from 60 to 100 bushels an acre. Land suitable for rice production must have a "hardpan" soil, some inches below the plow depth, to prevent the too rapid disappearance of water needed for irrigation.

Livestock. Livestock raising is largely in its infancy throughout the Gulf Coast States. With the clearing of the pine lands, however, successful stock farms have come into existence. The drainage on the hill lands is vastly superior to that of the alluvial or flat lands and tends to cause better health. Bermuda grass and Japan clover either grow voluntarily or can be introduced, yielding the most nourishing combination pasture in the South. Hundreds of cars of fat cattle, hogs, sheep, and goats go to the large Gulf markets and a surplus reaches northern centres. Goats and sheep are extensively used to graze newly cut-over pine lands. These lands are free from briars and the herds can keep down the young brush without damaging their fleeces.

The wet prairie lands of the Gulf Coast region are being drained by great dredges, which build up high walls around the reclaimed land from which the water is then pumped. The soils are of exceeding fertility.

Dairying is making progress throughout the Gulf Coast States and large profits attach to the enterprise whenever the dairy farm is located near a reliable market. Farmers have found it practical to raise their feed on the marsh or alluvial lands and allow their herds to roam the cut-over pine hills and flats.

From a sanitary standpoint the Gulf States region is an entirely different place from what it was ten years ago. There is in progress a general campaign to eradicate the mosquito. Screens are everywhere in use. Artesian wells in Louisiana, Alabama, Mississippi, and Florida give forth the purest water, which has had much to do with the general improvement in health. The future of this region is assured, since its agriculture has been adjusted to the needs of its conditions and its markets.

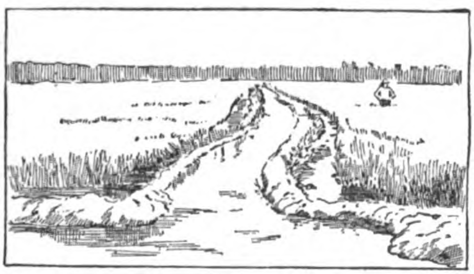


FIG. 118. A rice field, showing irrigation ditch and banks to prevent flooding when not desired

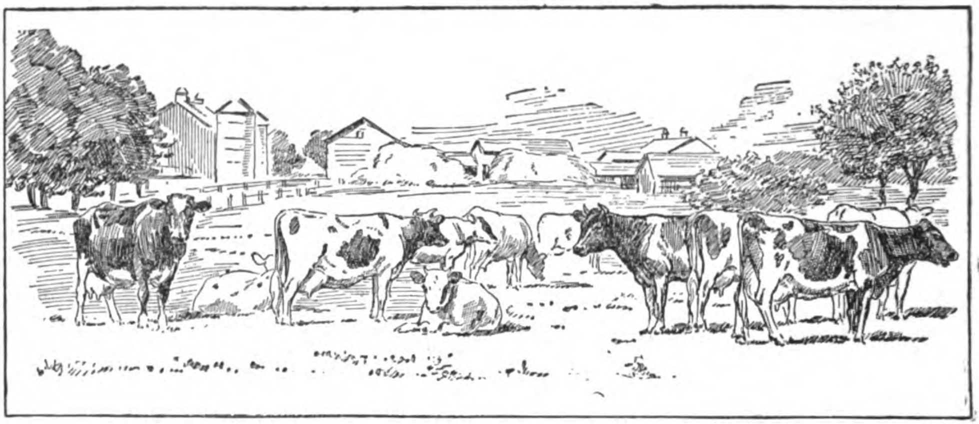


FIG. 119. Good land, good buildings, and good cattle are characteristic features of the North Central States

CHAPTER 14

Farming Systems in The North Central States

By VICTOR H. SCHOFFELMAYER (*See Chapter 11*). *The agricultural development of most of the newer parts of the United States has been fairly easy—a matter of finding the crops best adapted to the fertile soils and helping them grow. In the country discussed here, the pioneer work has been a warfare against a stern Nature among mighty forests and severe weather conditions. The success attained tells of the natural riches of the section and of the hardihood of the men who have developed it. The future is bright for both the land and its owners.*—EDITOR.

THE North Central States lie north of the Corn Belt States and embrace Wisconsin, Michigan, Minnesota, North and South Dakota. With the exception of the two latter states, which properly belong to the Great Plains and Rocky Mountain Uplift, the region is composed of glacial drift. Through this drift, in many places, the streams have cut channels, sometimes to a depth of 100 to 200 feet, leaving high bluffs along the stream beds. Older formations reach the proportions of mountain ranges and are located in northern Minnesota, Michigan, and Wisconsin. They reach elevations of more than 2,000 feet. The average altitude of these three states is 750 to 1,000 feet. The central plain of Wisconsin, the prairie of lower Minnesota and the flat lands of lower Michigan are ancient lake beds. The larger part of the Dakotas is prairie extending westward to a broken country called the Bad Lands. In the southwest portion of South Dakota are the Black Hills, rising to a height of more than 7,000 feet.

Originally Michigan, Wisconsin, and northern Minnesota were covered with forests of both hardwood and of pines and other conifers. Large areas were under water, bogs, swamps, and undrained prairie places being numerous. The northern portions of these three states have large areas of rough, hilly land, not well suited to farming. Michigan is largely surrounded by the waters of lakes Huron, Erie, Superior, and Michigan. Northeastern Minnesota fronts Lake Superior, as also does northern Wisconsin, while the latter's eastern shore touches Lake Michigan.

Soils. The soils of Michigan, Wisconsin, Minnesota, the greater part of North Dakota and the eastern half of South Dakota are glacial deposits of high fertility and quickly responsive to skilled farming methods, but there are also large sandy areas underlaid with heavy gravel and clay. Alluvial lands along the Mississippi River in Minnesota and Wisconsin are rivaled in productivity only by the rich drift soils and black loams in the limestone region of Minnesota. The Red River bottoms are famous and extend from Minnesota into North and South Dakota. The loam soils of the eastern Dakotas and the alluvial soils of the Missouri River flood plain are among the most productive soils known.

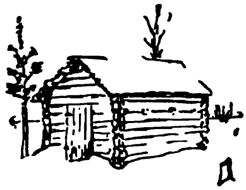


FIG. 120. The log cabins of the pioneers—

Climate. The average annual temperature of the North Central States varies from 39 in the northeastern districts to 47 in the southern. Summer extremes reach 100 above and winter temperatures drop to from 30 to 50 degrees below zero. The frost-free period is considerably shorter than in the Corn Belt but the hot days of summer with many hours of sunshine hasten the growth and maturity of crops. The Great Lakes locally affect the climate of Wisconsin and Michigan, tempering the weather and preventing many extreme and sudden changes in temperature such as occur farther west. Cold, wet springs frequently cause delay in planting and other farm work. The annual rainfall, much of which comes during the growing season when it is most needed, averages 30 to 40 inches in Wisconsin, Michigan, and lower Minnesota. Upper Minnesota and eastern North and South Dakota have 20 to 30 inches a year. The western regions of the Dakotas are semi-arid and have only 10 to 20 inches. Snowfall in the North Central States is generally heavy, but as there is but little alternate freezing and thawing, it is not as objectionable as are lighter snows farther south.

The people. The population of the North Central States is among the most progressive and enterprising in the United States. There is a large foreign element composed chiefly of Germans, Norwegians, Swedes, Danes and several Slav peoples. The early settlers built log cabins and grew patches of corn, potatoes, and rye, but most of their time was devoted to the marketing of forest products. So the early cities that sprang up were "built primarily upon the industry of the woodman's ax rather than the farmer's plow." Following the lumber camps and cities, which owed their existence to lumbering, came other population centres, their prosperity depending upon the farms. At the same time, in the Minnesota iron range and in the Michigan copper and iron belts, cities containing thousands of consumers of agricultural products were springing into existence. Later came the great manufacturing centres, and these are each year growing in numbers and importance. The result is that in recent years the more easterly portion of the North Central States has been transformed into a great factory and industrial region. To retain the farm population the states are coöperating toward the opening of the cut-over forest territory and inducing settlement. As a result farm operations have been pushed considerably northward with marked success.

Industries, manufactures, and commerce. A large part of the population of the eastern section of the North Central States is engaged in mining. Minnesota is the largest producer of iron ore in the United States and Michigan leads in production of copper. Low transportation rates on the Great Lakes are one of the chief factors in the development of the mining industry. The centre of the automobile manufacturing industry is in the North Central States, Detroit leading all other cities in this field. Minneapolis is the nation's greatest flour milling centre. St. Paul is one of the greatest livestock and packing cities of the country. Grand Rapids is a leading producer of furniture and fixtures and Milwaukee is an important brewing centre, as well as the home of cheese factories, creameries and yeast laboratories. Other important industries of the North Central States produce lumber and lumber products, condensed milk, paper and wood pulp, leather goods, leather, boots and shoes, furs, brick and tile, steel, engines and machines. The sawmills are moving northward, followed by the farmer.

All northern trunk lines to the Pacific Coast traverse the North Central States, radiating from Chicago. In point of transportation, the north country is well supplied with a magnificent network of railroads and excellent and numerous Great Lake ports. From the latter a fleet of specially designed freighters carry the products of the region eastward and southward. An enormous trade with the Pacific Coast is also carried on. The upper Mississippi River is navigated extensively between St. Paul and St. Louis. All northern rivers are largely used to float

FIG. 121.—Are rapidly giving way to comfortable farm houses built on productive, well-managed farms

rafts from logging camps to the saw mills. The leading cities and markets are Detroit, Milwaukee, Minneapolis, St. Paul, Grand Rapids, La Crosse, Sioux Falls, Fargo, Kalamazoo, Saginaw, Bismarck, Deadwood, and Lead.

Farming Conditions

It is somewhat difficult to consider this group of states as an agricultural whole. Not only do conditions in Minnesota, Wisconsin, and Michigan differ greatly from those in the Dakotas, but they are also unlike those in the other agricultural states. This is due to the unusual soil formations, to the northern latitude and to the climatic influences of large bodies of water. In North and South Dakota, the early settler found a seemingly never-ending prairie covered with a dense growth of wild grass, with only a few trees near the streams. Here the first step in farming was to break the prairie sod and to plant the newly-plowed land to flax or some other crop. This was in direct contrast to conditions in the heavily-timbered tracts of the three lake states where clearing the land and getting rid of stumps presented the first big problem. In view of the land hunger of the American people and of those who have come to our shores from foreign countries, it may seem strange that such conditions have so long continued. However, there are several easily understood reasons why the development of a region where agriculture can be made permanently profitable has not, until recently, been rapid: (1) Decided differences in soil presented not a single problem but many. The early homesteader found land covered with standing timber, cut-over timber lands, sand areas, and lands requiring drainage before they would be fit for farming. The system that would work under one of these conditions meant failure in another. (2) The heavily-timbered tracts of Minnesota, Wisconsin, and Michigan, while at first making possible ready money returns through the sale of lumber, ties, and other wood products, required slow, expensive, agricultural development. Especially was this true before modern methods of clearing and of ridding the land of stumps were generally used. (3) The stretch of cheap and easily-cultivated lands to the south and west drew many settlers, and western- and southern- grown crops competed with the products of this territory. Canada, too, made successful bids for settlers from the States. (4) In many cases at first crops from seed obtained through southern sources proved

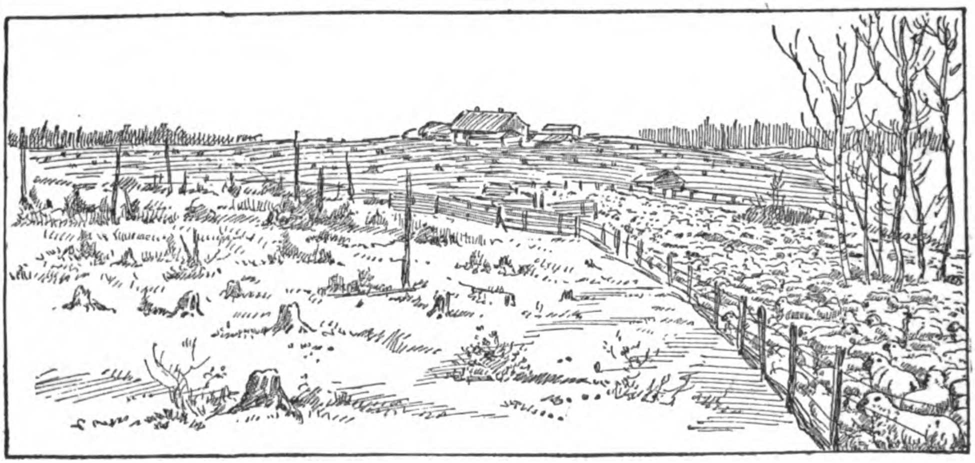


FIG. 122. Sheep are particularly adapted to both the climate of this section and the subduing of virgin, timbered, and logged-off lands

failures but this has been overcome through the introduction and development of more hardy barley, alfalfa, corn, and other staples. In this the work of the agricultural experiment stations and of the state agricultural colleges has been of great value. (5) The long and rigorous winters, which called for warm dwellings for the people, more expensive barns and stables, and frost-proof cellars for storage of root crops, were looked upon with misgivings, so that special agricultural advantages, including a deep and responsive soil, ample rainfall during the growing season, and comparative freedom from disastrous droughts and severe summer storms, were frequently overlooked. (6) Still another setback to the country was found in unwise and sometimes dishonest exploitation. Tracts of pure sand lands were sold to the unsuspecting city man who was led to believe that he had bought a valuable farm. For a while, too, the "townsite" scheme was overworked and "paper towns" sprang up in many places. Added to this harmful work of the white man, the Indian tribes caused considerable trouble.

Thus it was natural that settlement in North and South Dakota should have been slower than in states having somewhat similar soil and surface conditions, but a warmer climate, and located nearer good markets. However, with proper crop adaptation and improved transportation facilities, the agriculture of these states is rapidly developing, notwithstanding scant rainfall over the western parts.

General lines of farming. As the agriculture of this group of states assumes a more permanent form several distinct lines are revealed. Dairying easily ranks as a leading industry. In 1909, Wisconsin, in which state the dairy industry centres, produced 148,906,910 pounds of cheese, or 46.4 per cent of all that made in the United States. In addition to cheese, butter and other dairy products, the state has also become a leading source of supply for states which are in the market for cows. Each year hundreds of carloads of cows and calves are shipped south. Wisconsin is also noted for barley production. The growing of fruits, truck, and vegetables is a distinct industry within itself in those districts peculiarly suited to such production. General farming, including livestock breeding and feeding, is important but perhaps less so than in the Corn Belt. In the western part of the group, grain growing and the grazing of livestock lead, but general farming, wherever rainfall is sufficient, is growing in favor. Crops suited to the various soil and climatic conditions are being planted and are yielding rich returns. For instance, in Michigan, where there is much rich, heavy reclaimed muck land and where the summers are comparatively moist, the growing of celery has become a most important industry. Choice celery land frequently rents for $50 to $100 per acre. Onions are also extensively grown on the muck lands.

In the same state, along Lake Michigan, is a famous peach belt, made possible through the temperature-modifying effects of the lake. In fact, the state as a whole takes very high rank in fruit production. On the sandy, loamy soils of these states millions of bushels

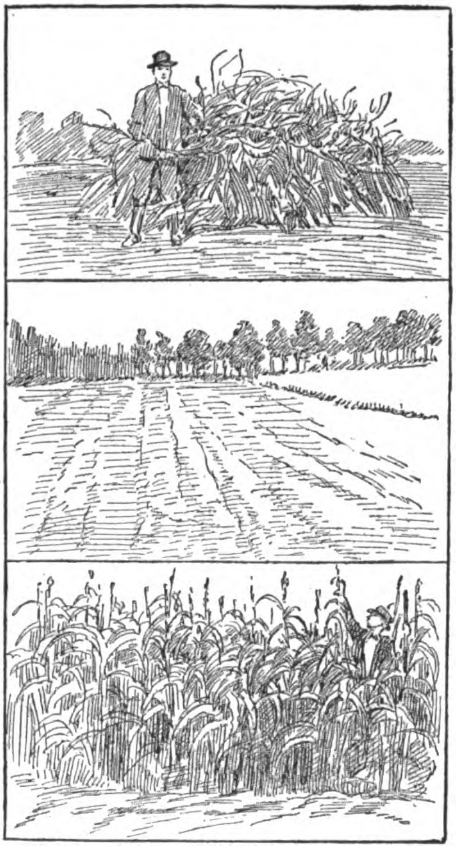


Fig. 123. Three years' activities in settling the northern country: first, land clearing and stump burning; second, seeding to grass and clover; third, the raising of grain. (Wis. Bulletin 260).

of potatoes are grown. As the livestock industry has developed the growing of crops for winter feeding has taken on added importance. Peas and oats make excellent succotash hay; mangels, rutabagas, turnips, carrots, and all root crops do well; corn, especially for fodder and silage, is grown on many farms. In North and South Dakota, flax, hemp, and hard wheat have been found admirably adapted to conditions. In brief, the one big problem of this group of states—adaptability, getting the right crop in the right place—is being met. Generally speaking, the soil is deep and capable of producing maximum crops over long periods. However, even though this is true, rotations should not be neglected. Many of the new lands are deficient in nitrogen and for this reason some legume should have a place in every system.

The leading grain crop of the North Central States is wheat, of which this region yielded 311,712,000 bushels in 1915. Drought reduced the 1916 production greatly. About 18,000,000 acres are annually seeded to the crop around which an enormous industry has been built up. Thousands of elevators to store the annual crop have been erected throughout the North and great mills eagerly bid for the crop to grind it. Northern wheat is specially noted for its high content of gluten in contrast with the high starch content of southern, soft wheat. These states have adjusted themselves to the farming opportunities of their territory in a surprisingly short time. Beginning with wheat, rye, flax, and hay crops, they gradually developed hardy varieties of corn which withstand the comparatively cooler nights of the North, and mature profitable crops. Proximity to large cities, such as Chicago, Cleveland, Detroit and other manufacturing centres on the Great Lakes has stimulated agricultural effort. There are large areas in the northeastern part of the five states which are just beginning to be developed.

The dairy industry has reached a high state of development in Wisconsin and Minnesota and heads all other agricultural pursuits. Wisconsin leads the United States in the number and value of her milch cows, which total 1,750,000, valued at $113,765,000. There are 10,061,000 head of cattle in the North Central States, of which 4,851,000 are milch cows, valued at $315,350,000. There are 90,000 silos in this region, with Wisconsin leading all states with 55,998. The extensive development of the dairy industry has brought about a system of coöperative creameries, which are operated in a manner making it possible for the small farmer to engage profitably in dairying. Cow-testing associations have become general, with the result that fewer non-paying cows are being kept.

Improved varieties. Varieties of alfalfa which are not easily winterkilled have been introduced and developed. In this field the work of Prof. N. E. Hansen of the University of South Dakota, who spent several years in foreign lands in search of hardy varieties has been notable. In Minnesota there was developed what has come to be known as Grimm alfalfa, which to-day occupies a standard place among North Central States crops. So hardy is this variety that every year its culture is pushed slightly farther northward. Other special crops acclimated to the North are drought-resisting emmer, spelt and allied cereals. These are of prime importance to the farmers of North and South Dakota, especially in the regions of 10 to 20 inches of rainfall. Far reaching has been the work of the Wisconsin College of Agriculture, which, through Prof. R. A. Moore introduced purebred barley, wheat, oats, and rye, distributing the seed through the agency of thousands of its short-course students. Most of the latter were practical farmers and they eagerly availed themselves of the opportunity to improve the cereals in their communities.

Livestock. As a beef cattle section the North Central States rank high. The Dakotas originally were a great grazing area. The difference to-day is that many of the cattle are not only grazed but also are fattened with home-grown corn silage, forage, and alfalfa hay. Southern Minnesota and Wisconsin have large regions where blue grass pastures keep herds of cattle throughout the grazing season. In the more westerly territory of the Dakotas, pit silos are filled with corn, kafir and other sorghums.

Sheep raising is gaining in popularity. Michigan has about 2,000,000 sheep out of a total of 4,000,000 for the North Central States. The sandy soils and the rough hills in all of these states have available grazing lands, which cannot be better utilized.

Hogs are produced on many of the farms of the North Central States. Thousands of dairy farms owe a large part of their profit to the combined feeding of cattle and hogs. In 1917 there were almost 8,000,000 hogs in the five states. The value of good blood in livestock of all kinds is generally recognized, so that there is but little scrub stock.

Special crops. Flax is one of the important farm crops of the North Central States. North Dakota leads in production with an average annual yield of more than 8,000,000 bushels, valued at $20,500,000. Minnesota and South Dakota are close competitors. Wisconsin leads in the production of hemp with more than 7,000,000 pounds. Michigan leads the United States as a raiser of beans, utilizing a part of her lighter sandy soils for this crop. The average yield is 12 to 20 bushels an acre.

One of the most productive potato-raising sections is the Red River Valley of Minnesota, North Dakota, and part of South Dakota, which yields large crops of seed potatoes, of which many are shipped to the South. In 1916, Minnesota led with 17,000,000 bushels of

potatoes out of a total crop for the five states of 57,100,000 bushels. Lower Michigan and southern Minnesota and Wisconsin are other important potato-raising sections. The wild hay of the prairies and marsh lands is an important crop, being in demand by dairymen and feeders.

Truck raising is rapidly becoming one of the most flourishing activities in the states of Wisconsin, Minnesota, and Michigan. The nearness of the large Great Lakes cities has stimulated this industry. Hundreds of thousands of acres of specialized crops are grown every year, including celery, cabbage, cucumbers, tomatoes, onions, green peas, lettuce, asparagus and roots. In one section of Michigan, in 1916, more than 50,000 acres were planted to cabbage and cucumbers, the latter for pickling purposes. The rate of increased truck acreage during the last few years has been very great. Most of this crop is hauled by lake steamers.

The orchards of the eastern group of the North Central States take high rank as producers of apples and peaches. Michigan, with almost 13,000,000 bushels of apples in 1916 was fourth among all the states. Apple orchards are being extended throughout South Dakota. Cherries, strawberries, gooseberries, currants, pears, plums, and blackberries and raspberries are commercially grown in favored parts of Michigan, Wisconsin, and Minnesota.

The North Central States have a total of about 8,000 farm tractors, North Dakota leading with 2,250 and South Dakota following with 1,643. These two states, because of their prairie-like character, are especially well adapted for power tractors and farming on a large scale.

Prospects. A most excellent spirit of coöperation exists on the part of farmers, business men, and bankers. The agriculture of the North Central States is assured of continued rapid development, because of the clearing of hundreds of thousands of acres of virgin hardwood and pine forests and the introduction and development of crops suited to the soil and climatic conditions. State forces of every character have combined with every legitimate organization working for the development of farming in the North to bring about the successful settlement of vast areas now being lumbered.

While there are old settlements in these states, much of the region is agriculturally new. Already wonders have been worked, but there remain great tracts of valuable land to be developed, and fine opportunities await settlers who are not afraid of farm work.

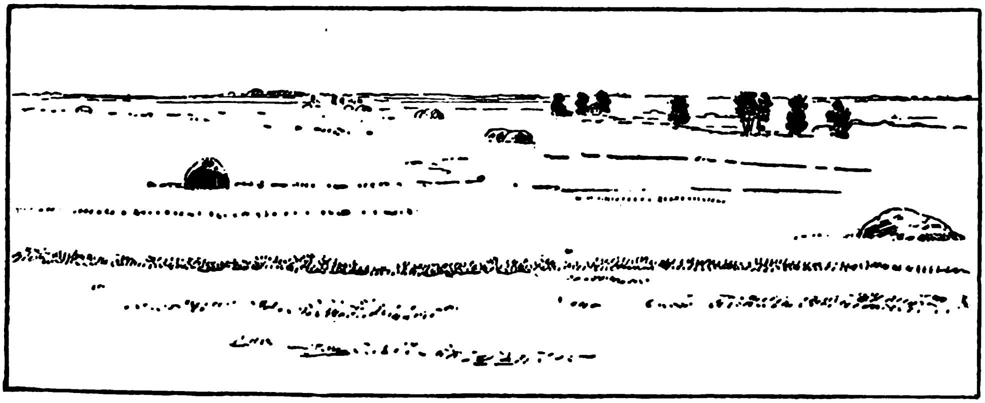


FIG. 124. The Platte country is flat and uninteresting to look at, but its soils are deep and of abounding fertility

FIG. 125. One of the most important features of the mountain section (despite its name) is its wide, level prairies, on which for many years were raised the beef cattle that provided the nation with meat

CHAPTER 15

Farming Systems in the Mountain States

By VICTOR H. SCHOFFELMAYER (*See Chapter 11*). *This vast section of the country covers more than 865,017 square miles, contains some of the most remarkable of natural features, and has been the scene of almost miraculous developments in agriculture. It is a land of bigness—big risks and big possibilities.*—EDITOR.

THE Mountain States are located west of the Corn Belt, Cotton Belt and North Central States, extending from the Canadian to the Mexican border. They lie entirely within the arid region and include Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, and Arizona. As far as their elevation and land surface are concerned, they occupy distinct regions. The largest is that of the Great Plains, with altitudes of 4,000 to almost 8,000 feet above sea level. The second is made up of the Rocky Mountain highlands, with their valleys, foothills, and plateaus. Third, there is the Great Basin, a desert region, covering the entire state of Nevada and the western third of Utah. The fourth division is the Inter-Mountain region of Idaho and Montana. The highest elevations of all are found in the mountains of Colorado, Wyoming, Montana, and Idaho, in many cases exceeding 14,000 feet.

The Rocky Mountains are covered with heavy forests of Western yellow pine, spruce, fir, tamarack and other cone-bearing species. Oaks and elms grow in the foothills. The plateaus and ridges are the home of the cedar, pine, pinyon, and juniper, whereas along the rivers of the Great Plains the cottonwood, elder, and willow grow abundantly. Scattered over the Mountain States are large sandy wastes unable to sustain useful plant life unless artificially watered; here only sagebrush and cacti grow. In southern Colorado, New Mexico, and Arizona occur broken-surfaced areas traversed by dry river courses. Also there are numerous tablelands that arise suddenly from the surface of the plains. None of the rivers is navigable but many are used as sources of great electrical power, as well as for irrigation purposes.

Soils. The soils of the Mountain States vary greatly in fertility. The Great Plains are covered with fine loam, lacking enough humus for best results but productive under proper tillage. At the southern end the plains soil is known as adobe, a type of heavy clay. The fertile valleys of Montana give the impression of prairies. In Idaho the volcanic and limestone soils are highly productive. Large areas in the Great Basin are alkaline, rich in alkali and consequently infertile; similar spots are found in New Mexico and

Arizona. River-formed soil of highest fertility is usually found along all important river courses in each of the Mountain States except Nevada. Even the very sandy soils throughout this region respond to irrigation.

Climate. The climate of the Mountain States is exceptionally dry, healthful and invigorating. On the Great Plains, the average annual temperature ranges from 37 degrees in northwestern Montana to 69 degrees in New Mexico and Arizona. The Inter-Mountain region averages 55 degrees. Winter temperatures of 20 to 45 degrees below zero are on record in the northern tier of states. While equally high summer temperatures occur in the south, the dry climate keeps them from being seriously unpleasant. Idaho and Utah climates are moderated by "Chinook" winds, caused by a warm ocean current that comes from Japan across to the Pacific Coast. Hot days and cold nights are characteristic of Nevada. Throughout the Mountain States the frost-free period varies with the elevation and the shelter provided by encircling mountain chains. In the highlands it is not more than 100 days or from June 1 to September 10. The growing season lengthens from about 120 days in Northeastern Montana to 150 days in Utah and Colorado and 170 days in lower New Mexico. The average annual rainfall on the Great Plains ranges from 6 to 20 inches. The mountain regions receive from 20 to 40 inches the precipitation being greatest at the highest elevations; of course, no farming is practised. In the Great Basin, the annual rainfall ranges from 2 inches to 10 inches. Heavy snowfall in the mountain ranges adds considerably to the available moisture supply for irrigation.

Population. Many Eastern, Northern and Central States have contributed heavily to the population of the Mountain States. The quest for gold and other precious metals brought the first settlers. Later followed the cattlemen and sheepmen who seized upon the vast grasslands as pasture for their herds and flocks. Lastly came the farmers, including many foreigners—Germans, Scandinavians, Bohemians, Russians, Poles and Austrians. The rigorous climate, characteristic of the larger part of the mountain regions and the strenuous independent life it makes possible and often necessary, have welded this mass of humanity into a vigorous whole, full of enterprise and determination. With the exception of Denver and Salt Lake City, there are no large cities in this region. By far the largest number of people live on farms and in mining camps or towns contiguous to the mines. Educational progress has been rapid and schools have been established in every community. Especially noteworthy is the efficiency of the institutions which devote themselves entirely to the study and teaching of mining engineering and reclamation. Agricultural colleges and experiment stations maintain large forces of county agents in the farming sections.

Industry and commerce. The leading industry of the Mountain States is the mining of gold, silver and copper. Great smelters are located at Denver, Butte, Pueblo and Raton. Other industries are lumbering, manufacture of butter, cheese and condensed milk, brick and tile, leather goods, art pottery, meat packing, metal refining, and quarrying.

All railroads to the Pacific Coast pass through the Mountain States, 10 trunk lines crossing the continental divide either by northern, central or southern passes. Transportation facilities, therefore, are of the most advanced type in spite of the great distances involved. Difficult engineering problems have been solved to unite the mountain regions with the great Middle Western markets and the ports of the Pacific. The chief markets within the Mountain States are Denver, Salt Lake City, Pueblo, Colorado Springs, Butte, Boise, Great Falls, Cheyenne, Helena, Ogden, Santa Fe, Albuquerque, Phoenix, Leadville and Reno.

Until comparatively recent times, the Mountain States were not considered an agricultural region. The short growing season did not seem to permit the raising of crops. But years of experimental work and practical operations have had their effect in developing an agricultural system well suited to the conditions. There has been a steady increase in farm production throughout this region in contrast to a decline in mining activities in several important states. Indications point to greater agricultural and livestock growth than ever before as the farming systems of the region are still farther developed and perfected.

Farming Systems in the Mountain States

There are two distinct types of farming in the Mountain States, each adapting itself to certain conditions and each with its enthusiastic advocates. Both are highly successful under proper management and each is partly responsible for the remarkable development of the section that has taken place during the present century. *Dry-farming*, as it is called (see.Chapter 5) is in general use throughout the Great Plains, the foothills and parts of the Inter-Mountain region. *Irrigation-farming* chiefly follows the valleys of rivers having sufficient water to insure a supply necessary for crop production.

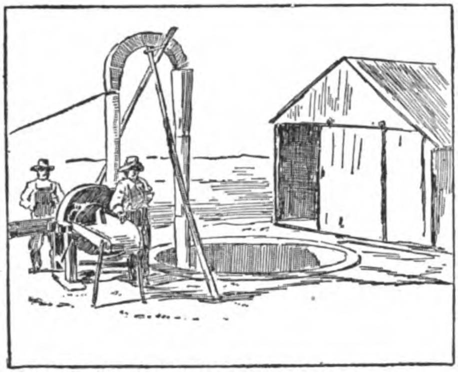


FIG. 126. Filling a pit silo—one of the striking features of the semi-arid mountain country

Dry-farming, as practised to-day, is an established, successful system of storing all available moisture in the soil at the time the rain falls and depending upon it to mature a crop. It was evolved only after years of misdirected energy and many attempts with unsuitable crops. The first settlers on the Plains vainly tried to raise wheat, although practically no rain fell during the winter months. Year after year the crops literally were blown out of the ground by the persistent dry winds. When the basic principles as well as the merits of dry-farming finally were understood, farmers began to adapt themselves to it. It succeeds up to elevations of nearly 8,000 feet.

The dry-land farmer who plows or lists his fields in the fall so that they may store up the moisture from winter rain and snow, will have a proper seedbed for spring planting. During the summer the rainfall of the Plains averages from 10 to 20 inches, which is enough for a number of crops provided there has been collected and held the needed moisture in the soil ready for planting time. Where soils are deep it is advisable to plow to a depth of 8 to 12 inches and more and maintain a soil mulch by frequent cultivation of the crop rows.

Special drought-resisting crops have been introduced into the arid regions by the Federal Government. Among these the most important, commercially, are kafir and its cousins—milo, feterita, kowliang, durra, broom corn, Egyptian wheat and the saccharine sorghums. The yields of such grains range from 15 to 40 bushels an acre under average tillage methods and there are official records of crops that have been made with less than 6 inches of rainfall during the growing season.

Under the old cattle-ranching system, livestock was grazed over the Plains as long as the grass was sufficiently abundant; when it became too short, the cattle were sent east to be fattened in the corn belt. It finally became apparent that the range cattle need not be sent away to fatten if the proper feed could be grown at home. It became a matter of conserving all the feed grown, and to meet this need there was developed the pit silo—a hole dug in the ground in which silage, made from kafir, cane or dry-land corn, was stored till needed. This, too, has had a great effect on the development of the agriculture of the Great Plains. The West is gradually raising its own food supplies and shipping its finished livestock both eastward and westward.

Experiments made by agricultural stations have resulted in introducing drought-resisting varieties of alfalfa, sweet clover, etc. These are a great aid to the dairy farmer, who is rapidly displacing the cattleman on the Plains near the larger industrial centres and markets. Dairy cows do exceptionally well in the dry-land regions.

To give an idea of the crop possibilities of dry-farming, there may be mentioned the following crops, all of which have been successfully grown: Corn, oats, barley, rye, field peas, beans (pinto and other varieties), kafir, milo, feterita, kowliang, durra, emmer, potatoes, onions, cabbage, garden truck and cantaloupes.

Irrigation farming is one of the most profitable and popular types of systems now followed in the West. Millions of acres to-day are being watered and forced to produce bountiful crops. The fact that for ages no moisture has leached away the soil fertility explains why even the sandier soils prove highly productive as soon as they come into contact with water. It is generally agreed that where less than 10 inches of rain falls during the year irrigation is essential to crop production. Abundant water is crop insurance.

Alfalfa is the principal farm crop under irrigation. It grows in New Mexico and Arizona at elevations above 6,000 feet. It excels all other western hay crops in yield and value. Three to 5 cuttings an acre are not uncommon in the southern portion of the arid region.

Dairying and beef cattle raising have logically followed the growing of alfalfa, and the production of cream and butter is one of the chief sources of income. Creamery stations are located at regular intervals. The excellent mountain roads insure quick delivery.

Certain districts in Utah, Idaho and Colorado have become famous as potato sections, the best results being obtained by alternating the crop with beets and grains in order to prevent potato diseases.

Other Farming Activities

Beet sugar production is one of the great industries of the Mountain States. The beets are grown under irrigation in Colorado, Utah, Idaho, Montana, and

Arizona. In the latter state they are grown as both winter and summer crops. Large sugar factories have been erected in several Western states, and the industry in past years has surpassed the cane-sugar production of the South.

Fruit raising has also become one of the most profitable undertakings in irrigated districts. Apples, cherries, plums, pears, berries, cantaloupes, peaches, apricots, almonds, grapes, and citrus fruits are grown, depending upon the locality.

One of the interesting details of fruit raising in the Inter-Mountain districts of Colorado, Utah, and Idaho is the value of locating with reference to air drainage. It has been found that certain valleys have a continuous flow of air which prevents frost from injuring the fruit buds of apple and other fruit trees. Where this current of air does not exist, it is hazardous to try to raise fruit.

In certain sections of New Mexico, Utah, and Colorado, the pinto bean is an important crop, largely because of the high prices received for it. In the dry-land sections, the beans yield 10 to 15 bushels an acre; under irrigation, 20 to 25 bushels.

The Inter-Mountain districts of Utah and Idaho are successful wheat-raising sections. Sufficient rain falls during fall and winter to permit fall seeding, and the crop is harvested before the dry period arrives. Under similar handling, barley, oats, and rye yield profitable crops.

Agriculture in practically all Mountain States is now on a safe basis. The tendency to gamble in wheat crops has received its death blow through repeated failures to raise it on soils not adapted to it and in regions deficient in moisture. More attention is being paid to the raising of purebred cattle, Wyoming being a leader in this field. Thousands of silos have been built and filled with high-altitude corn or kafir, making 5 to 6 tons of silage an acre at elevations of almost 7,000 feet. Sudan grass is generally seeded where alfalfa will not grow.

Millions of hogs and sheep are grown, the latter especially in sections not yet under intensive cultivation. New Mexico has found Angora goat raising profitable in the mountain valleys and on the high mesas or table-lands. In the more enterprising districts of Colorado, Idaho, Utah, and Montana, farm tractors are in common use. The level lands permit the use of all improved farm machinery. Hundreds of thousands of acres of homestead lands have been settled in practically all the Mountain States, except Nevada, in the last 10 years. The tendency to abandon these, at one time strikingly common, stopped with the solution of the main farming problems of the section. The development of great irrigation projects in Arizona has made that state an important producer of long-staple cotton, citrus fruits, grain and hay crops.

The large cattle and sheep ranches continue to flourish, but on a revised basis which involves the production of most if not all their own feed. While the limits of dry-farming are being extended systematically, there is a pronounced preference for irrigated lands due largely to the possibility of improving the living conditions.

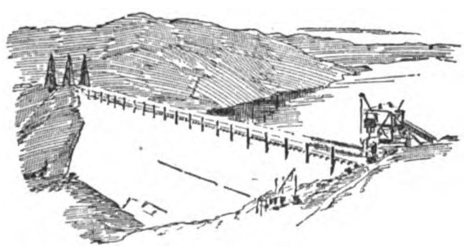


FIG. 127. The Elephant Butte dam, typical of the vast engineering feats that are irrigating many of the dry but fertile lands of the Mountain States.

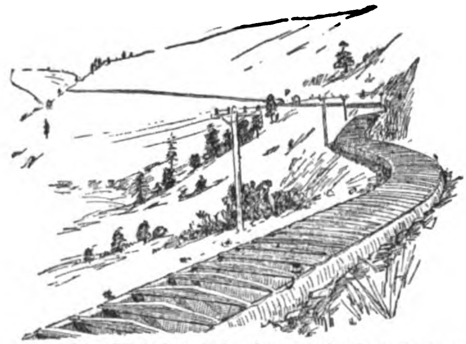


FIG. 128. High line irrigation canal of concrete on the Yakima Project, Washington. (Illustrations in this chapter from photographs supplied by the U. S. Reclamation Service.)

CHAPTER 16

Farming Systems in the Pacific Coast States

By C. J. BLANCHARD, *statistician of the U. S. Reclamation Service since* 1904, *and before that in charge of a special investigation of irrigation conditions. An important feature of much of his work since he attended the Iowa Agricultural College has been the study of farming activities and developments in different parts of the country and their description by means of lectures and articles. Few men enjoy better opportunity for watching the agricultural growth and the tendencies in the Far West, where irrigation is a vital issue but by no means the country's only resource.*—EDITOR.

THE Pacific Coast region, including the states of Washington, Oregon, and California, occupies a position of enormous importance to the nation. In but a short span of years it has changed from a wilderness peopled by savages, to a group of commonwealths of agricultural and commercial greatness. Even in the brief period since they joined the sisterhood of states, each of the three has expanded far beyond the dreams of its pioneers who braved the dangers of desert and mountain in opening up its trails.

The total land area of the section is 318,095 square miles, or nearly 11 per cent of the whole United States not including Alaska. California, ranking first with 155,652 square miles, is the second largest state in the Union; Oregon covers 95,607 square miles; and Washington, 66,836 square miles. The total population in 1910 was 4,192,146 or about 13 per square mile. Actually, however, 75 per cent of the population is centred in relatively small areas on the coast, leaving a larger portion of each state but thinly settled. Conservative estimates indicate a population increase of 60 per cent or more since the last census.

As far as climate and other natural features are concerned the three states taken as a whole possess many similar characteristics. Each is crossed roughly from north to south by rugged ranges of mountains including the highest peaks in the country. Smaller ranges branch off from these and in some places enclose large areas of valley and table lands. The north and south ranges, by their influence on the rainbearing winds off the Pacific Ocean, have created three distinct regions in each state as regards rainfall and moisture; namely, humid, semi-arid, and arid.

The Semi-Arid Region

What it is. Agriculturally, the larger part of each state belongs in the semi-arid region. The annual rainfall, either because it is slight or because it comes at the wrong season, limits the farm crops mainly to cereals, usually wheat or barley; in many sections it compels the practice of summer fallowing or cropping once in 2 years. Scientific dry-farming methods have been successful in many places and have resulted in the taking over for agriculture of large areas once regarded as unproductive. The precipitation records in these semi-arid areas for 10 years or more, show great and irregular variations which make it impossible to give definite limits to the areas which may be described as truly semi-arid or arid. Farming under such conditions is, therefore, somewhat hazardous and should not be undertaken except by men of means and experience. By the use of power machinery and the cultivation of tracts of 1,000 acres or more, men familiar with farming in this country are able to lessen greatly their chances of failure.

Extensive areas of these semi-arid lands are still public domain, and home-seekers are flocking to them. To these a word of caution: Before taking up a home in this region, carefully study the rainfall records for at least 10 years, if possible. If, during that period, there have occurred several years when the rainfall was insufficient for cereals, choose another location.

Broadly speaking, three fourths of Washington and Oregon may be classified as belonging in this semi-arid belt. The soil over most of it is much the same, being composed largely of decomposed volcanic rock or ash with here and there ancient lake beds of rich loam. It varies in depth from a few to 100 feet but it is all rich in minerals—iron, lime, potash, and phosphoric acid.

In Washington and Oregon

Wheat growing. The semi-arid regions produce the bulk of the wheat crop of each State. In Washington on the tablelands of the Columbia, on the slopes and foothills of the Cascades and the Blue Mountains and in the Okanogan highlands, are large areas given over almost exclusively to wheat growing. In Oregon, in the northeast along the Columbia River, on the eastern and southeastern plateaus and in the southern part of the state near the California line, many thousand acres are adapted to this crop. The elevated table lands, the foothills and mountain slopes receive the greater rainfall and crops are usually certain. At varying distances from the mountains, the rainfall becomes less regular and abundant and the region gradually changes from semi-arid to arid. Along this shifting line of division is found the greatest number of failures.

However, we may be reasonably sure that we do not know all there is to learn about wheat growing in regions like these. Our methods are still primitive and careless; selection of proper seed is often disregarded; and furthermore, we have yet to produce (as we shall produce) seed which, through its drought-resisting qualities, will overcome in part the absence of timely showers.

General farming. Within a comparatively few years, the farming methods in this region have shown marked changes. The wheat grower is diversifying; he has added livestock to his resources with the growing of forage crops for winter feeding. The dairy industry waxes greater each year. Over the vast plains and plateaus and in the national forests, hundreds of thousands of sheep graze in the summer contributing in wool and mutton to the wealth of each State. The climate is extremely healthful and moderate throughout the entire semi-arid section.

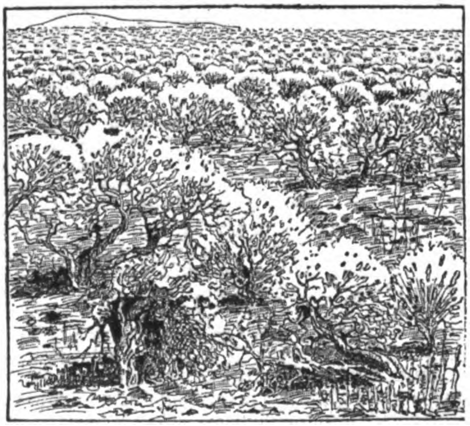


FIG. 129. Irrigable land on the North Yakima Project, Washington, before reclamation

FIG. 130. Typical timber in the forests of the North Pacific Coast country

In California

California's semi-arid belt occupies a large part of the state's arable area. It extends from the northern limits south to the Tehachapi Range and from the eastern side of the Coast Range to the slopes of the Sierras on the east. It includes a part of the Great Central Valley of California, a broad depression constituting one of the state's most striking features and presenting an exceptionally interesting field for agricultural development. The valley includes 2 drainage basins, that of the Sacramento on the north and that of the San Joaquin on the south, the larger part of the latter's being classified as arid.

In the northern counties. The rainfall is usually ample for growing grain. For many years, large areas here have been producing wheat and barley without irrigation. In former times, some of the largest wheat ranches in the world were found here, but soil exhaustion followed continuous cropping, yields fell below the profitable point and attention was finally turned to the construction of irrigation systems taking water principally from the side streams and only occasionally from the Sacramento itself. The development of power from the Sacramento and its tributaries, the growth of placer mining and manufacturing, together with questions affecting the use of the river for boats furnish varied and perplexing problems which must be solved before the greatest and most beneficial use of the river can be made. In these northern counties, the climate is similar to that of Oregon and Washington, the winters being mild and, except in the mountains, free from heavy snows; the summer nights are usually too cool for corn. Wheat, oats, barley and timothy do well. In all sections where diversified agriculture is practised, however, irrigation is essential. In connection with wheat raising, the farmers in the northern part of the state are heavily interested in livestock, beef cattle, swine and sheep. The dairy industry is increasing in importance each year.

In the Central Valley. The rainfall might suffice for grain growing if it came at the right time but it doesn't; the summers are long, hot and often for months without rainfall. Winter is the wet season. Temperatures in the main valley are seldom below freezing. Citrus and other tender fruits are here remarkably free from frost danger.

This valley, from the slopes of Mt. Shasta on the north, to the junction of the Sacramento and San Joaquin on the south, includes an enormous and productive area of valley and rolling prairie lands awaiting development. Irrigation through conservation of stored waters in artificial reservoirs, drainage of swamp and overflowed lands, and the rotation of crops on the hill lands, when successfully accomplished, will add millions to the taxable wealth of the State and will furnish homes for many thousands of families. Progress in this direction has been very rapid in the past decade. The great wheat and barley ranches have almost disappeared, countless small farms having taken their place. The dairy, sheep and swine industries have grown with the increase of irrigation and in their wake, the creamery, condensery and cheese factory are following quickly. Almost every form of farming known in this country is found in this valley. The transportation needs are exceedingly well served by the Southern Pacific with two main lines through the valley from north to south and numerous branches extending to the eastern and western sides.

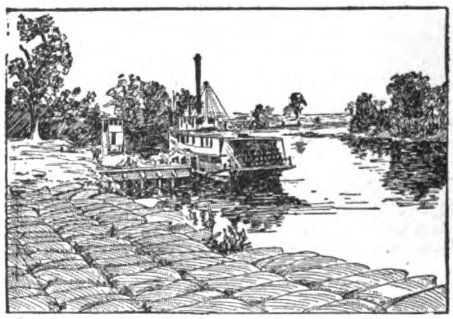
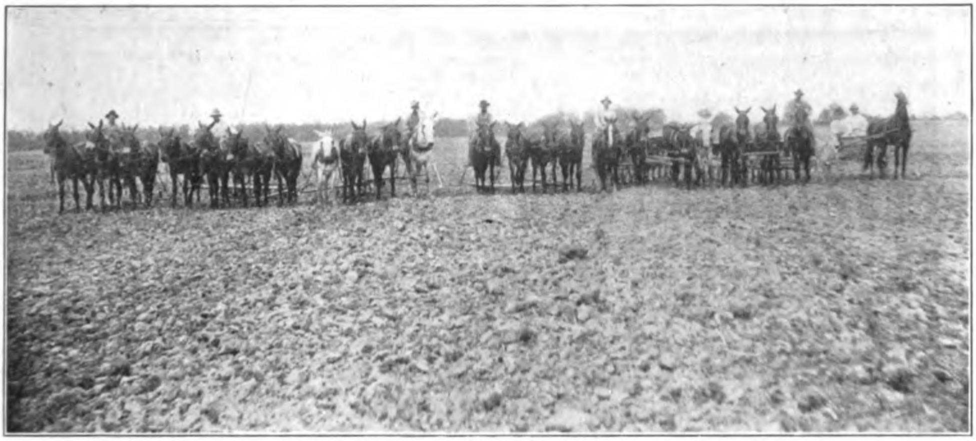
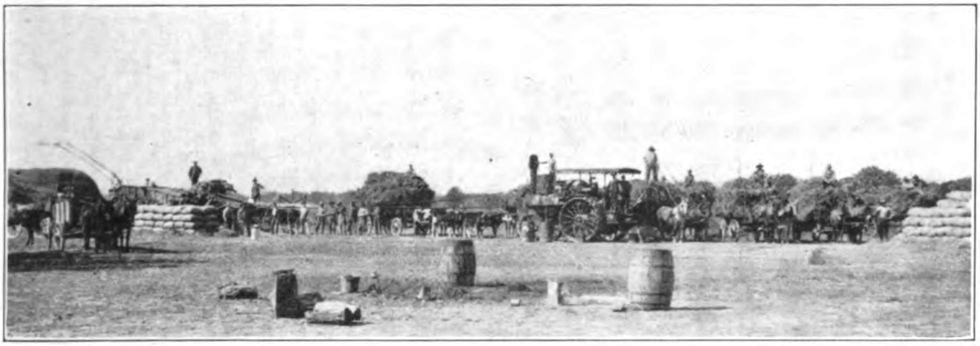


FIG. 131. Scene on the Sacramento River, California



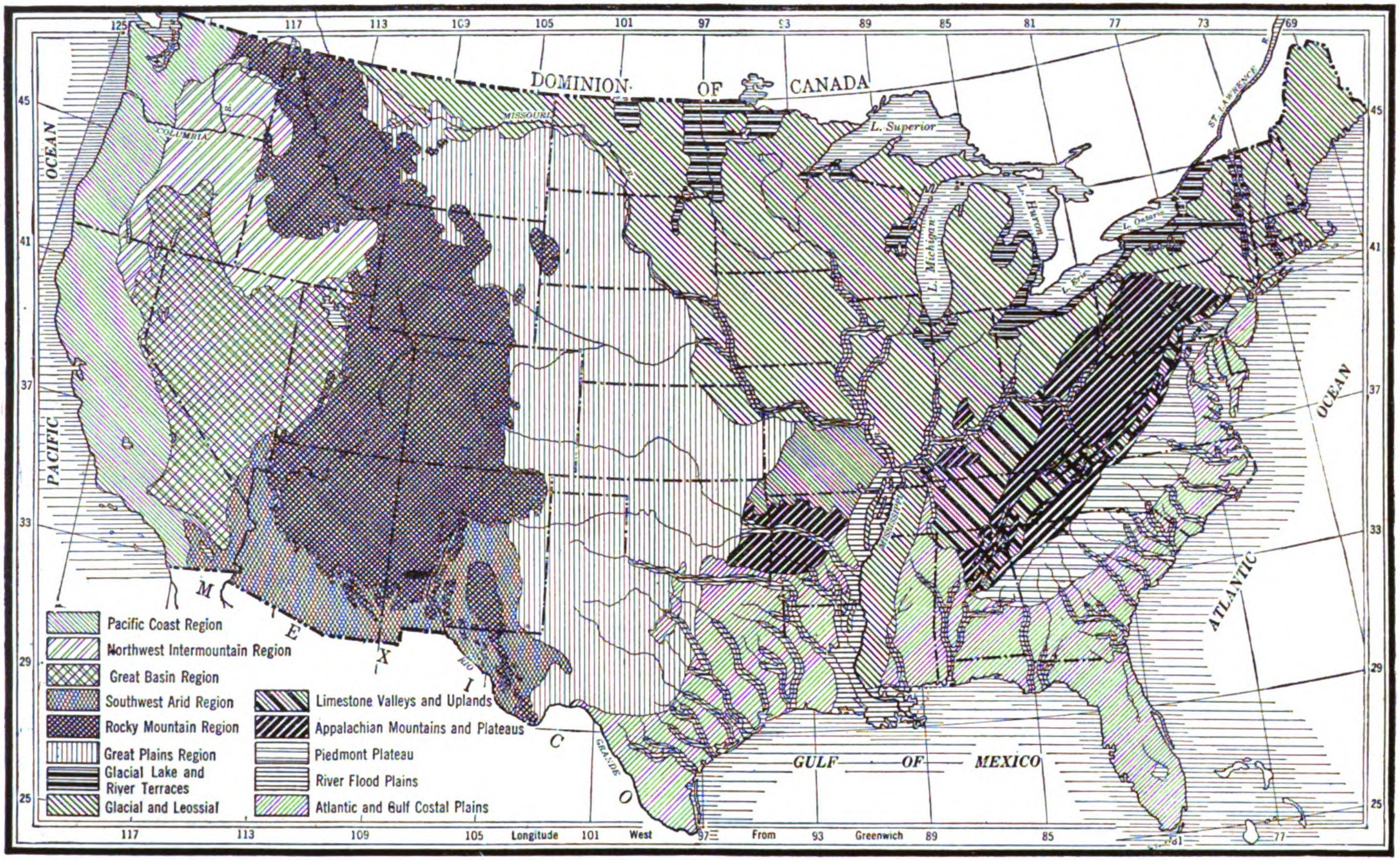
Breaking the ground for rice in Louisiana



And, at the other end of the season, threshing a 5,000-bushel crop

It is as if we harvested all the warmth of summer with the golden grain, leaving the land in the cold, hard hands of winter until another planting season comes round

GOOD FARMING DIFFERS NOT IN PRINCIPLE BUT ONLY IN METHOD, WHETHER IN THE GULF COUNTRY OR ON THE PRAIRIES OF THE NORTH



The Soil Provinces and Regions of the United States. These Provinces are Divided into Series, and They into Types, each of which has its Special Farm Characters and Values. See Chapter 1, Page 14. (U. S. Bureau of Soils.)

The Arid Regions

These may roughly be described as follows:

1. The valleys of the tributaries of the Columbia River and of tributaries east of the Cascade Mountains in Washington and Oregon.
2. The southern half of the Central Valley of California.
3. Practically all of California south of the Tehachapi Range to the Mexican boundary including the sunken desert known as Imperial Valley and the valley of the Colorado extending north to the Needles.
4. An extensive area lying east and southeast of the Sierras embracing Death Valley, 290 feet below sea level and the lowest point in the United States.

In Washington. The only parts of these arid regions that have any agriculture are, naturally, those areas in which irrigation is used. Washington's principal irrigated areas are located on the Yakima, Okanogan and Snake Rivers, the valley of the first named being the largest and most highly developed in the State. It contains approximately half a million acres of irrigable land adapted to intensive cultivation and when irrigated, producing heavy yields. The products of irrigated farming are numerous, including wheat, oats, barley, corn, potatoes, sugar beets, vegetables, apples, peaches, pears, apricots, small fruits, English walnuts, hops, and others. On the Government irrigation project in 1916, 70,000 acres showed a gross return of $73 per acre, probably the largest average acre revenue ever shown on a tract of similar size in this country. In the valleys of the Okanogan and Wenatchee, are considerable areas of fertile lands which are producing fruit of excellent quality. In the lake and river regions about Spokane and in the narrow valleys along the Snake River in the southern part of the State, considerable irrigation is practised and a variety of crops, many of which are high priced, are raised. Washington's fruit industry has expanded greatly in the past decade. The trees of bearing age number more than 12,000,000 and in average years the product is valued at $10,000,000.

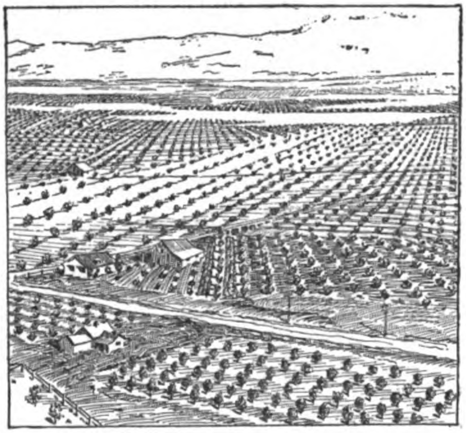


FIG. 133. A valley scene on the Okanogan Irrigation Project, Washington

In Oregon. Arid Oregon is only slightly developed. Great problems of storage and power development remain to be undertaken before the vast region can be reclaimed. More than 12,000 square miles of this territory is without railroad transportation. Oregon's irrigated districts are situated mostly in the valleys of streams tributary to the Columbia except in the extreme southern portion where development of irrigation has taken place from streams which flow into the Pacific or are lost in natural sinks. Snake River and its branches furnish water to the largest areas, but the lesser tributaries of the Columbia like the John Day, Deschutes, Umatilla, Hood and Walla Walla Rivers contribute to many thousands of acres. Approximately one fourth of the irrigated acreage of the State is supplied from streams which have no outlet to the sea. These drain a large area in the southeastern part of the State which constitutes an arm of the Great Interior Basin of the West. Alfalfa is the principal crop, as this region is given over largely to livestock.

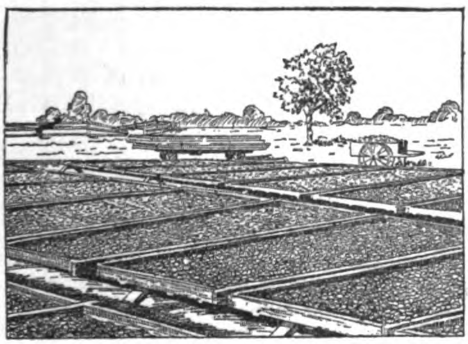


FIG. 132. Drying almonds in California

The principal orchard districts are in the valleys of the Rogue and Umpqua rivers and along the Columbia. Oregon's orchards contain approximately 8,000,000 bearing trees, yielding annual crops worth $6,000,000.

In California. The San Joaquin Valley of California has an area of 11,500 square miles or more than the combined areas of Delaware and Massachusetts. In the variety and abundance of its products and in the fertility of its soil, it is rated as one of the richest agricultural spots in the world. Only a small portion of its arable area is producing at this time. While the irrigation systems are numerous and many are of modern construction, little effort as yet has been made to conserve the flood waters which are wasted each year, but which, if stored, would reclaim hundreds of thousands of acres of valuable land. A number of excellent opportunities exist for development either by the Government or the State. Complex problems hinging on conflicting water rights have heretofore delayed any step in this direction. The valley lands produce a large variety of crops including those of the temperate and semi-tropical zones. This region is noted for its yields of peaches, plums, pears, apricots, oranges, lemons, limes and grapes. It is also a favorable location for dairying and swine raising.

South of the Tehachapi Mountains, all land values depend directly upon the ability to obtain a water supply. The rivers are small and erratic, the population is dense and the farms are among the smallest in the United States. Here water is so precious that careful consideration is given to the various methods of supply and distribution. Surface water, drainage water, seepage water, water from artesian wells and from tunnels penetrating the mountains, and water impounding in large and costly reservoirs—all these are utilized. This region leads the United States in diversity of methods of application, in scientific distribution and conservation, and in the expensive character and boldness of design of its irrigation works. There has resulted a prosperous and growing commonwealth in a region which without water would be a scene of utter desolation. Seventy per cent of the acreage irrigated from wells in the United States is located here. Surrounding the cities of Los Angeles, San Bernardino, Riverside, Redlands and Santa Barbara—are thousands of acres of citrus orchards, vineyards and seed gardens of every variety. Land values are probably the highest in the country for property of this kind.

The orchards of California as a whole contain 30,000,000 trees of bearing age producing annually 38,000,000 bushels of fruit valued at $22,800,000. The value of citrus fruits alone probably exceeds $30,000,000 annually.

The most recent important development in southern California has taken place in the delta of the Colorado River extending from the Needles to the Mexican line. By diverting water from the Colorado River, a large area with climate, soil and crops similar to the Nile Valley of Egypt, has been reclaimed. Opposite Yuma, Arizona, and in the extreme southeastern part of California, two projects have been completed, and the desert has begun to blossom. The greater area thus developed is known as Imperial Valley and embraces nearly 300,000 acres, all of which is below sea level. Agricultural development here has been little short of miraculous. Vast areas are in alfalfa, cereals, long-staple cotton, and dates; thousands of acres are planted annually to cantaloupes which are shipped to eastern markets in trainloads; dairying, livestock feeding and kindred industries are successfully established and are prospering.

The total acreage under irrigation in each of the Pacific Coast States in 1910 was as follows: California, 1,196,767; Oregon, 368,911; and Washington, 160,483. This gives a total of 1,726,061 or 16 per cent of the entire area in crops that year. The crops were valued at $67,540,893, an average of $39 per acre.

The Humid Coastal Region

Between the Coast Range of mountains and the Pacific Ocean, and extending from northern Washington well down the coast of California is a fringe of land varying in width from nothing to 100 miles, and distinguished from the two regions already discussed by its abundant rainfall. In this region are located the section's chief centres of population, commerce, and manufacturing. Its important natural resources are enormous forests, representing billions of dollars; numerous excellent harbors, large water-power sites, and unlimited quantities of fish of many varieties.

Agriculturally this region is not nearly as important as either the arid or the semi-arid division. Because of the extent of its timbered area, its farming lands are confined to small valleys along the streams, the slopes of bare hillsides, and logged-off lands which have been cleared at heavy expense. However, excellent climate and soil and abundant rainfall characterize all the cultivated areas. Crop yields are heavy; the world's record yield of oats is claimed by Washington. The season is open nearly the year round, and pastures are green from March to December. Under such conditions the dairy industry has made great strides. Creameries, condenseries, cheese and butter factories abound in Washington and Oregon. Purebred strains of milch cattle have been introduced and the business is on a

firm and substantial footing. Future opportunity for expansion of agricultural industries depends upon the clearing and cropping of large areas of logged off lands. At present, the first cost of such a clearing is too high for the poor man; an investment ranging from $50 to $150 per acre is required before much of the land can be cultivated.

The largest manufacturing industry of this region is lumbering in which several millions of dollars are invested. Shipbuilding has been greatly helped by the war.

The tidal rivers and the ocean waters teem with food fish, and canneries are located along the coast at many points, their output finding ready market all over the world.

Along the coast are the great cities—Seattle, Tacoma, Portland, San Francisco, Oakland, Los Angeles, and San Diego, which dominate the financial and commercial interests of the Pacific Coast. They furnish a home market for the products of the soil, and are distributing and shipping centres for all surplus products.

Summary. Judged by its progress during the past 10 years or so, the future of the Pacific Coast section seems assured. Moreover, it contains undeveloped resources in greater variety than may be found elsewhere. The homeseeker who demands a climate that is livable, a soil that has depth and lasting fertility, and social conditions which encourage homebuilding, must find this region attractive.

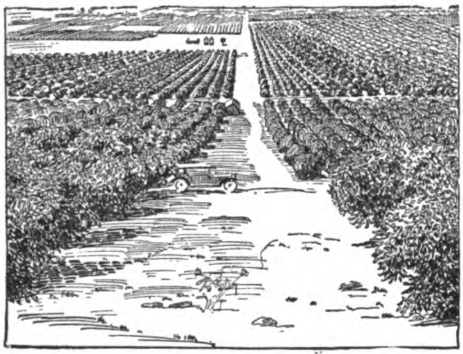


FIG. 134. An orange orchard near San Joaquin, Cal.

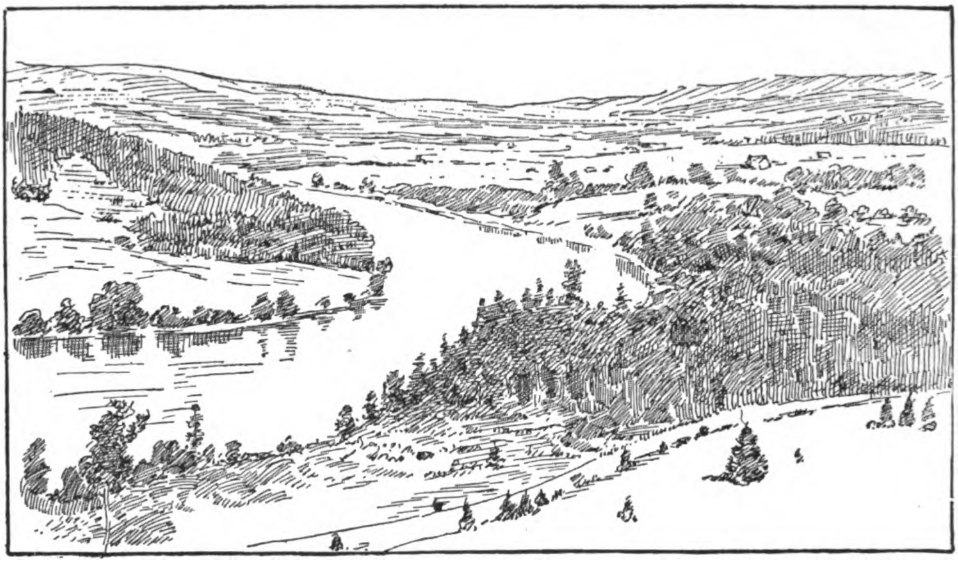


FIG. 135. Typical country where the Laurentian Plateau and the St. Lawrence River meet

CHAPTER 17

Farming Systems in Eastern Canada

Considering the wide range of opportunities for agriculture that are offered by the different sections of the United States, it may seem unnecessary to discuss in this book conditions outside our National boundaries. However, Canada is part of this continent and of this country—naturally if not politically—and the farming problems of our neighbors and how they solve them are always of interest, whether or not we are able to profit by them in our own work.—EDITOR.

QUEBEC

By DIRECTOR J. H. GRISDALE *of the Experimental Farms of the Dominion of Canada, Ottawa, Ontario, who is also Acting Deputy Minister of Agriculture for the Dominion.*

MOST of the agricultural lands of Quebec lie in the valleys of the St. Lawrence River and its tributaries. From the mouth of the Ottawa, which comes from the north to join the St. Lawrence and which forms the southwestern boundary of the province, the fertile northern watershed stretches eastward along the St. Lawrence. It rises gradually to the northward through bottomland and clayey plateau to rough foothills giving a spread of arable land ranging from 50 to 10 miles in width. It disappears entirely just below the Island of Orleans, where the Laurentian Highlands and the St. Lawrence meet. The southern watershed, beginning where the international boundary runs into the St. Lawrence and continuing for nearly 200 miles to the eastward, is rather of the nature of a plain. It varies in width from 10 to 80 miles and is drained by a number of modest rivers running northward to the St. Lawrence. These rivers rise in the rolling, hilly and even slightly mountainous region lying south and southeast of the river beyond the plains, and commonly known as the Eastern Townships. While many of the

farms here are rough, the lands are, nevertheless, nearly all taken up and many excellent horses, cattle, and sheep graze on the rolling pastures and fertile bottoms of these foothills of the Appalachians.

Farther to the eastward, the arable areas of the province are confined to a strip skirting the lower reaches of the River and Gulf of St. Lawrence and the northern shores of the Bay of Chaleur, a strip rarely, if ever, more than 20 miles wide, and often narrowed down to almost nothing, as the low, heavy hills crowd down toward the waters of tide and river.

To the north of the St. Lawrence Valley and beyond the Laurentian Range, lie the watersheds of several fine rivers flowing toward Hudson Bay. These rivers drain much excellent land, quite heavily wooded and being opened to settlement by the National Transcontinental Railway. The arable area of the province may quite possibly be increased by 50 per cent through the opening up of this heretofore unexploited region, rich in timber, water power, and fertile lands.

Crop products. The great staple crops are oats and hay. Barley, wheat, buckwheat and rye are grown to some extent but are of much less importance than oats. Corn for silage, roots to a limited extent, and potatoes are also grown in greater or less quantities in most parts of the province. The turnips and potatoes grown in the more easterly districts are of a very superior quality and command a premium on most Canadian and American markets to which they can be delivered.

Market gardening, small fruit production, orcharding, poultry keeping, and various other minor activities are found in the more westerly and southwesterly areas. One industry of considerable consequence is maple sugar making. It not only has a financial interest to the farmer but is of some importance from what might be called the sentimental side since its beginnings date back to earliest Canadian history in the first years of the seventeenth century. Its pursuit is, in many cases, a matter of pride and pleasure as well as of money gain. On both sides of the St. Lawrence from Montreal to Gaspé and north and south of the river for many miles, the early spring sees many thousands of farmers busily engaged tapping, boiling and sugaring-off in the extensive maple woods of the country.

Livestock. The livestock interests of this province, while very considerable, fall far short of what they might be in proportion to the area under cultivation and in view of the favorable climatic conditions. While horse breeding of sorts is carried on in all parts of the province, it is only in the eastern townships that this industry assumes any material importance. Here export stock is produced and both quantity and quality are well worth considering. In other parts, the horses bred are of no special type and largely nonmarketable; light-weight horses, some of them of a blocky type, suitable for delivery work and general light farm work, are the class commonly bred. These horses are, to some extent, the descendants of horses brought over from Normandy, France, in the 17th century and resemble the horses of that country in some degree. A stud book for French-Canadian horses is in existence but the breeding studs maintained are few and small.

Beef cattle are found only in the Eastern Townships; even there they are in limited numbers and, for the most part, of inferior quality. The leading types are Shorthorn and Hereford.

Dairy cattle, however, are common the province over, and butter and cheese are the great staples of the province and by far the principal agricultural exports. The popular breeds are the Ayrshire, Holstein, Jersey and French-Canadian, but grades are very common.

This province has long been noted for the superior class of Ayrshires bred and handled on its farms, and great numbers are exported each year to the other provinces and to the neighboring republic. These cattle have been bred here almost as long as in Scotland. While found in numbers in every part of the province, they are very generally kept by the average farmer in the eastern townships. Holsteins are gradually increasing, but do not seem likely to oust the Ayrshire from first place in the favor of the Quebec dairyman. Jerseys are very few in number. French-Canadian cattle, a breed originated in this province, while found in all parts, are not at all numerous and in no district do they assume leading importance, although they are hardy, thrifty, profitable little cattle. Their breeders organized an association some 50 years ago and have a herd book.

ONTARIO

By **Director J. H. Grisdale** *of the Dominion Experimental Farms.*

THE range of natural conditions in this province is great since it extends on the north as far as Hudson Bay, while its southern extremity is about on a line with northern Pennsylvania. In the southeast, along the Ottawa and St. Lawrence rivers, soil and farming conditions are much like those on the other side of the Quebec boundary. Along Lake Ontario and Lake Erie, the coast is generally level or only gently rolling and here is found the highest and most intensive agricultural development. Bordering the northern plateau the land is rougher, often rocky, abruptly rolling and more or less heavily timbered. However, the province as a whole is mainly agricultural and general farming or stock raising are generally successful wherever more specialized industries are prevented by conditions of soil or land surface. The climate is generally moderate, especially along the lakes, with plenty of rainfall in all sections.

Crops. The staple field crops of Ontario are winter wheat, oats, barley, rye, buckwheat, timothy, red and alsike clover, alfalfa, corn for ensilage, potatoes, roots, and corn for grain. These, in varying proportions, are grown from the extreme east to the farthest southwesterly point. Cropping systems and cultural methods vary greatly according to the district considered and the particular class of stock kept on the farm. Summer-fallowing is practised to a limited extent in preparation for wheat. Fertilizer is applied to this crop, and on meadows, but most commonly on corn, either for ensilage or grain, and on roots. Practically the only fertilizer used is barnyard manure.

The rotation best suited to crop requirements and to soil and climatic conditions is generally admitted to be a 4-year one including one year each of a hoed (cultivated) crop, grain, hay and pasture. Although not universally followed, this, or some modification of it, is very widely practised. The hoed crop is usually followed by a spring cereal with which is sown red or alsike clover or the two of them and timothy. The resulting stand of grass and clover is left for hay for a year or two and then very commonly pastured for another year or sometimes longer. Where fall wheat is grown, it commonly takes the place of the hoed crops.

Practically the whole of the grain grown and all the forage crops produced, except a small amount of timothy hay, is consumed on the farms. Even this, however, falls short of the feed requirements for the livestock of the province, and large quantities of mill feeds are brought in annually, from the West. In this way the fertility of the province as a whole is increasing and its livestock carrying powers are growing gradually greater.

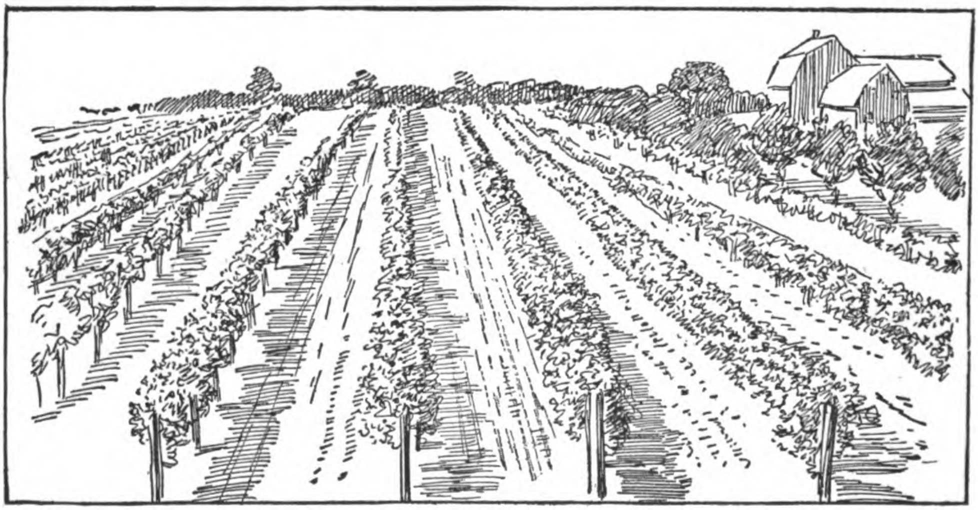


Fig. 136. Grape growing is but one phase of the intensive and highly successful fruit industry of Ontario

In addition to the staple crops mentioned, certain others are of considerable importance. Sugar beets of excellent quality are produced and manufactured into sugar in considerable quantities, and flax for fibre is grown to the extent of 6,000 or 7,000 acres each year. The resulting fibre, while not equal to the Belgian or Irish product, is superior to most of that grown in Russia, and much better than anything grown anywhere else on this continent. Alfalfa is being more and more widely grown and might now really be called a staple crop.

Fruit growing, though restricted mainly to the immediate borders of Lake Erie and Lake Ontario, has there been very highly developed. The fertility of the soil and an especially favorable combination of climatic conditions make possible the production of peaches, apples, grapes and other fruits of the highest quality. The farmers of this section are especially progressive and well organized with the result that their successful activities are well known and regarded in all fruit-growing districts of the country.

Livestock. For quantity, quality and variety of livestock, bred and fed within its borders, Ontario easily stands first among the provinces of the Dominion. Her draft horses, her beef cattle and her dairy herds are among the finest in the world and, while her flocks are not large, the quality of the sheep she produces has been demonstrated time and again at both the local and international shows. The swine and poultry interests of the province, while quite considerable, are not relatively so extensive, nor is the stock of quite such a superior character. Horse breeding is, of course, carried on over the whole province, but a very large proportion of the best stuff is found in the counties bordering on Lake Ontario and in that part of the province stretching away from Toronto and Hamilton toward Lake Huron and the Georgian Bay.

Curiously enough, too, while beef cattle are more or less numerous in practically every county, they also are most commonly bred and fed in the very districts where the heavy horse predominates. It must be added, however, that the beef breeds—Shorthorn, Aberdeen-Angus, Hereford and Galloway—are also quite popular in the more southerly and southwesterly parts of the province and also in the more northerly rough, rolling lands beyond the fertile plateau that varies from 40 to 100 miles wide and skirts Lake Ontario from Belleville to Toronto.

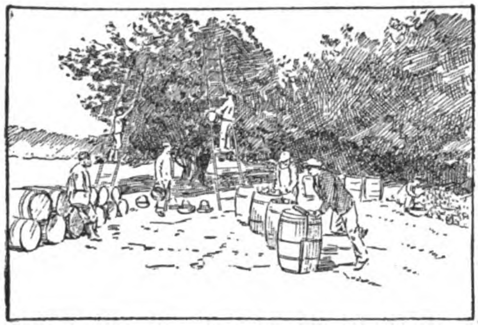


FIG. 137. Ontario fruit growers have perfected their marketing, as well as their cultural methods

Dairy herds of Holsteins, Ayrshires, and Jerseys and their grades and crosses are found in every county, but over the whole of the eastern part of the province as far west as Coburg and Peterboro and likewise in that group of central counties of which Woodstock is the chief city, dairying is the line of farming most commonly, if not exclusively followed. Holstein blood is the most common, with Ayrshire a poor second; there are but few Jerseys, comparatively. Apart from the milk and cream consumed raw in the cities and towns, Cheddar cheese, butter and condensed milk are the chief dairy products. They are, generally speaking, of superior quality and are exported in large quantities. Canadian Cheddar, as made in Ontario, is recognized as the best on the British market.

Sheep and swine are kept quite generally, but are most numerous and of best quality in the central, westerly, and southwesterly parts of the province.

NEW BRUNSWICK

By DIRECTOR J. H. GRISDALE *of the Dominion Experimental Farms.*

NEW BRUNSWICK, although one of the oldest settled provinces in Canada, is but sparsely populated and, from an agricultural point of view, one of the least progressive. The soils in the various river valleys are fertile and highly productive, but while the rivers are fairly numerous, the total area of such land is not very great in comparison with the whole area of the province. However, in addition to these hillside and bottom lands, there must be included, as of great agricultural value, some other special areas, such as the rolling plateau, mostly on the west but to some extent on the east side, of the upper St. John River; the fertile dike lands along the Bay of Fundy, especially in its upper reaches; and the more or less broken stretches along the Bay of Chaleur.

Crops. The staple crops are hay, oats, turnips and potatoes. Most remarkable crops of hay are harvested year after year off the dike and river bottom lands, and oats do well on practically all the arable lands of the province. The province seems to be the natural habitat of the turnip, and great crops are harvested every year. Hay, oats and turnips, but most commonly hay and turnips, form the beef-producing ration of the province and give results scarcely believable to those unaware of their possibilities.

Potatoes have long been recognized as the real New Brunswick crop. Results and profits obtained are truly remarkable and are probably equaled in America, for quantity, quality and certainty, only in that small part of Aroostook County, Maine, known as the Presque Isle district.

While they grow well and give great crops in almost all parts of the province, it is particularly on a strip some 30 or 40 miles wide on each side of the upper St. John River that potatoes are recognized as the one great crop, to the extent of dwarfing, if not wholly excluding, every other farming enterprise.

Livestock. Livestock work has been neglected for some years and while dairying is of some importance in the valley of the St. John and Kennebecasis Rivers, it can scarcely be said to be a staple industry. The export of butter and cheese is very small at best and not infrequently the end of the year sees a shortage for home consumption rather than a surplus for export.

Beef cattle of Shorthorn descent and moderate quality are fed in considerable numbers in the St. John Valley and on the dike and marsh lands. Here hay and oats are grown at great profit and on the adjoining higher land turnips and potatoes do astonishingly well. The beef stockers are raised to some extent in the interior, on rough, poor land, but the most of the breeding, as well as the feeding, is done on the dike lands and along the rivers.

Horses are bred to a very limited extent other than in sufficient numbers for the needs of the province. Light horses, of rather poor quality, are the rule.

Sheep do exceedingly well and are very profitable, but for various reasons are not popular. Swine are kept only in small numbers on account of the scarcity of suitable grains for fattening purposes.

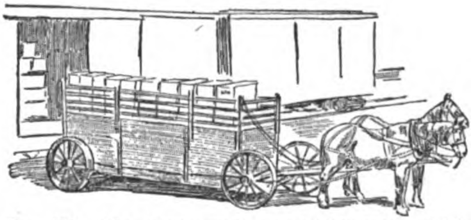


FIG. 138. The sloven wagon, a common work vehicle throughout the Maritime Provinces

PRINCE EDWARD ISLAND

By J. A. CLARK, *Superintendent of the Dominion Experimental Farm at Charlottetown in that province.*

DESCRIPTION. This province is generally called the "Garden of the Gulf" since almost its entire 1,397,991 acres is good, arable land, most of it being under cultivation. A ridge of hills about 30 miles long crosses the Island from north to south near its centre. The surface of the country east and west of this ridge is gently rolling and watered everywhere by great arms of the sea, which reach far inland forming great, navigable bays. Ninety per cent of the people live by agriculture. Most of their homesteads are sheltered by wood lots which supply them with lumber and give the countryside a homelike appearance like that of the farm sections of the British Isles.

Development. The early settlers under French rule came from Normandy. They fished and farmed, and groups of their descendants still fish and farm along the coast; but under this combined system the farming suffered as it is bound to suffer. Later settlers came from the British Isles establishing New London, New Glasgow, Kelley's Cross and other settlements in which they reproduced the farming methods and typical life of their native county, shire or province.

Wherever they came from, and wherever they settled down, they faced a common foe—the forest—which they felled and cut and burned. Then they cleared the stump-dotted land, each in his own manner, but all with characteristic British vigor, persistence and thoroughness. In the same spirit, they fought the absentee landlord, and finally rid the land of this injurious system.

Farming. Mixed farming with small holdings is characteristic of the whole

province. In early years, hay, oats, and other raw products were shipped to the old country in new vessels built in the Province, which were sold with their cargoes. At that time the Prince Edward Island 7-year rotation was followed, that is: oats, potatoes, wheat, hay (2 years) and pasture (2 years). For the last quarter century livestock raising and dairying have been the basis of farm systems that have rapidly restored the fertility that was being depleted by the earlier practices.

The apparently inexhaustible supply of mussel mud from the river bottoms is generously called upon to stimulate crop production and correct the tendency of the land to be sour. Four- and 5-year rotations suitable for dairy farming have come into use. The seed-grain and potato trade has greatly increased in recent years, while at the same time the Island has kept its enviable name in North America as a source of high-class hay, oats, horses, and potatoes. Under the stimulus and concentrating effect of coöperation the poultry industry now rivals dairying in the value of its output. With the improvement of transportation facilities, the excellent possibilities of the province along fruit and truck gardening lines should and undoubtedly will be taken full advantage of.

NOVA SCOTIA

By W. SAXBY BLAIR, *Superintendent of the Dominion Experimental Station at Kentville in that province.*

NOVA SCOTIA comprises the peninsula of that name and the island of Cape Breton with a total area of 21,427 square miles. Of the 1911 population of 492,338, about 54,000 occupied farms. These farms cover about 5,235,871 acres of which about one fourth is improved. Some 2,903,410 acres of this farm land is still in natural forest. The marsh area, made up of tidal deposits and for the most part diked, amounts to 266,562 acres. The area in field crops is 711,387 acres and in orchards 40,512 acres of which more than three quarters are in the three counties of Kings, Annapolis, and Hants, especially the first.

Agricultural conditions in this province are very similar to those in the New England States, and farming operations have been developed along much the same lines in both places.

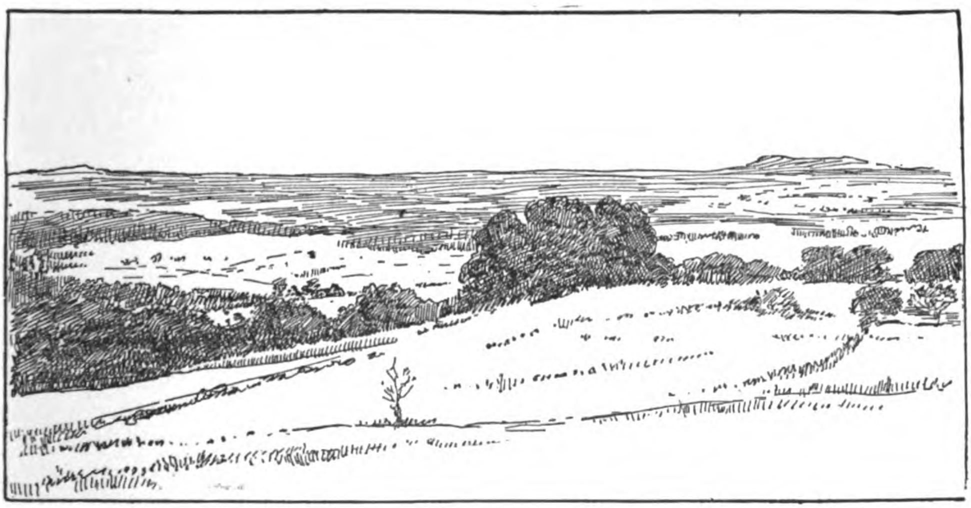


FIG. 139. View across the Laurentian Lowland country of Quebec

Outside of the fruit-growing counties of Kings, Annapolis, and Hants, farming operations are confined to the growing of the general farm crops and livestock. The dairy industry is making the most rapid progress and this in turn means greater production from the tilled areas. The area in farm crops has increased in the past few years from 10 to 15 per cent, and greater attention is being paid to better methods and systematic rotation of crops. Many of the unimproved lands are being brought under cultivation and larger quantities of grains and succulent fodder crops are being raised.

Crops. The principal grain crops are oats, of which 2,973,769 bushels were raised in 1911, wheat (223,033 bushels), barley (142,223), and buckwheat (206,005). The field forage crops are principally hay (724,393 tons), corn for forage (5,205 tons), potatoes (3,581,737 bushels), and turnips (3,080,976 bushels). The principal field crops are, therefore, hay, oats, potatoes, and turnips.

Owing to the moderate summer temperature with no very hot weather, corn has not been largely grown as a fodder crop. The turnip is the principal succulent stock feed, the climate being particularly well suited to it. Corn does well, however, and can be ripened in many sections, particularly in the western counties; it will no doubt be more generally grown in the future.

Livestock. Owing to the moist and cool climatic conditions the pastures keep in good condition throughout the season making the Province ideal for dairy purposes. Sheep raising is being rapidly extended and this industry will be double its present size in a very short time. The 1911 census figures for livestock were: horses 61,355, valued at $7,066,274; milch cows 129,302, worth $4,198,881; other cattle 158,122, worth $3,039,900; sheep 220,907 worth $870,560; and swine 63,322 with a value of $539,969. About $325,000 was found to be invested in poultry.

Fruit. The principal fruit grown is the apple of which 1,534,820 trees are bearing and 884,070 non-bearing. The yield is about one million barrels annually. But trees enough to double this production are rapidly developing. The fruit-producing counties have not kept up the production of farm crops and livestock in comparison with other parts of the Province, but have depended largely on the fruit crop for their income. As a result of insufficient livestock, the orchardists have had to rely on commercial fertilizers to keep their soils productive; probably greater quantities have been used in the three fruit-growing counties than in all the rest of Nova Scotia combined.

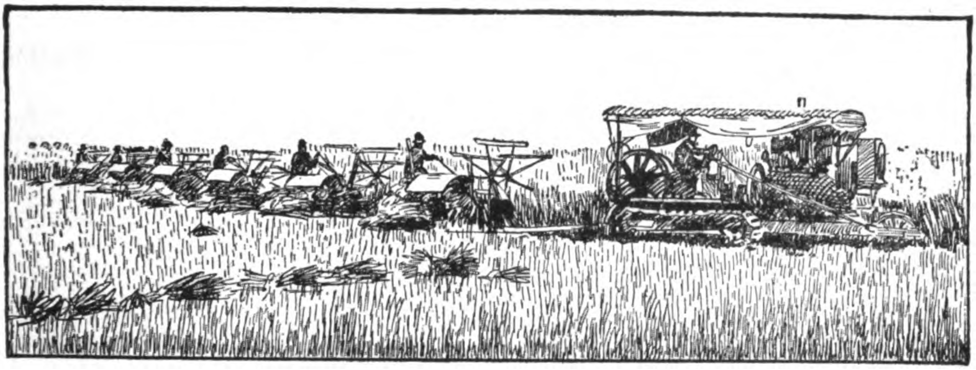


FIG. 140. The tractor has been a necessary factor in the wholesale methods that have developed the great Canadian Northern. (Illustrations in this Chapter, except Fig. 141, by courtesy of the Canadian Pacific Railway).

CHAPTER 18

Farming Systems in Western Canada

By CHARLES W. PETERSON, *Managing Editor of the Farm and Ranch Review, Director of 3 large farming corporations of central Alberta, and, during the war, Secretary of the National Service Board at Ottawa. He began farming in southern Alberta in 1889 and developed one of the show ranches of that province. In 1898, he became Deputy Minister of Agriculture for Alberta and Saskatchewan and later Managing Director of the Alberta Live Stock Associations. For a time he was Superintendent of Irrigation, then General Colonization Manager for the Canadian Pacific Railroad. All his varied activities, therefore, have kept him constantly in touch with practical farming.*—EDITOR.

WESTERN Canada, for our purposes, includes the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia. Up to the early 'eighties this vast country was practically uninhabited except around the scattered Hudson Bay Company posts, along the Saskatchewan and Red rivers where some agriculture had developed, and in the mining districts of British Columbia and Vancouver Island. The construction of the first transcontinental railway changed the situation; the laborers secured land all along the line and settlements sprang up over night. However, the agricultural development of the region has been comparatively slow. It is estimated that it contains to-day an area capable of agricultural development almost equal to the entire developed farming area of the United States.

Production. The following Government estimates of the value of leading products for one year suggest the ability of the section to produce wealth:

SECTION	GRAINS HAYS ROOTS ETC.	DAIRY PRODUCTS	FRUITS AND VEGETABLES	LIVESTOCK	MINERALS	LUMBER	FISHERIES
Manitoba......	$ 77,435,000	$17,575,470 (all four provinces)	....	$38,675,416 (all four provinces)	$ 1,819,921	....	....
Saskatchewan..	248,013,300		....		583,708	....	....
Alberta........	114,372,000		....		13,336,702	....	....
Br. Columbia...	15,232,000		$5,641,631		42,970,585	$35,528,000	$14,538,320

Total............$625,721,053

The Dominion Postal Census of 1916 showed the value of manufactured products in the four Western Provinces to be $180,958,089.

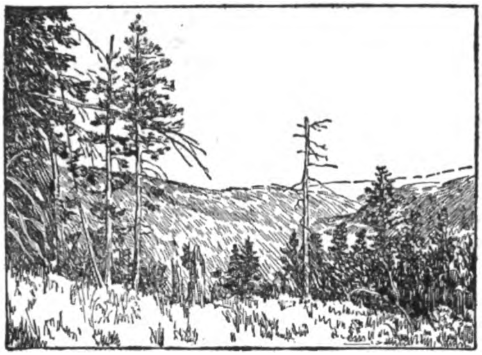


FIG. 141. Typical forested country in interior British Columbia

Climate. Generally speaking, the climate of the Prairie Provinces is severe in winter and warm in summer. Nights are generally cold. On the whole, it is a pleasant climate resembling that of North Dakota and Montana, the range of crops that can successfully be raised being about the same as in those states. Broadly, the rainfall is sufficient in every part of Western Canada to produce the common cereal crops successfully, providing dry land culture is adopted in the drier sections. The following table gives the average annual precipitation at two points which fairly well represents the country as a whole:

YEAR	LETHBRIDGE (Alberta)	BRANDON (Manitoba)
1909	16.15	18.01
1910	11.89	13.98
1911	20.04	26.03
1912	21.30	18.04
1913	17.38	12.00
1914	17.36	16.79
1915	17.27	18.18
Av. for 7 yrs.	17.34 in.	17.86 in.

Agricultural education and organization. Each provincial Government maintains a thoroughly up-to-date and well equipped Department of Agriculture. In Manitoba and Saskatchewan, highly efficient agricultural colleges are maintained at Winnipeg and Saskatoon respectively, and to each of these is attached an extensive demonstration farm. In Alberta there are 3 farm schools situated at Claresholm, Olds, and Vermilion, and in addition the Provincial Government conducts demonstration farms at Medicine Hat, Stoney Plain, and Sedgewick. The British Columbia government also does very advanced work, especially in fruit production. The Dominion Government has for many years maintained a chain of well-conducted experimental farms throughout Western Canada.

The Agricultural Society and the Farmers' Institute are flourishing institutions in Western Canada, being assisted by the various Provincial Governments, which provide for their organization. Expert judges and well qualified speakers are supplied for local fairs and meetings and for stock-judging classes by both Provincial and Dominion authorities. The membership fees are in all cases very small, the work being carried on almost entirely at the expense of the Governments. Farmers in the Prairie Provinces are especially well organized for business purposes. Grain Growers' Associations and Farmers' Unions control extensive coöperative elevator systems and coöperative purchasing departments.

Agricultural societies throughout western Canada hold annual shows, and large annual sales of purebred cattle and sheep are conducted by the Provincial Live Stock Associations at central points in each province.

The Geography of the Provinces

Manitoba. This is the oldest and the most eastern of the Prairie Provinces. Its first agricultural settlement was made in 1812 in the Red River Valley near the site of the present city of Winnipeg; but Manitoba assumed little importance as an agricultural country until 1878 when the first railway entered her boundaries.

Manitoba lies between the 49th and 60th parallels of latitude and is bounded on the east by Ontario, on the northeast by Hudson Bay, on the north by the Northwest Territories, on

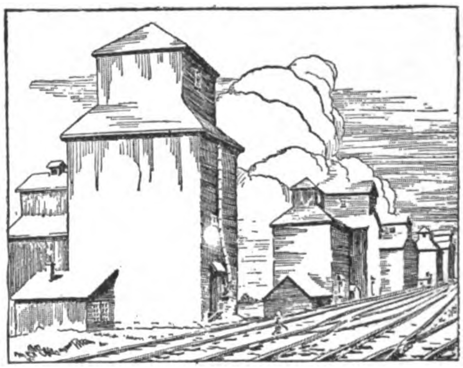


FIG. 142. The importance of grain is clearly shown by the scores of elevators that border the railroads

the west by Saskatchewan, and on the south by the states of North Dakota and Minnesota. It has an area of 251,832 square miles, and its estimated population at the end of 1916 was about 560,000. The newly added territory to the north has not yet been sufficiently explored to make possible any proper conception of its wealth, but there are large stretches of timber, big clay deposits, and minerals.

The principal products of the province at present are wheat, oats, barley, flax, roots, vegetables, livestock, poultry, dairying, cultured and domestic grasses, gypsum, clay, shale, limestone, gravel, sand, whitefish, and timber.

Saskatchewan. This province also lies between the 49th and 60th parallels and between the 102d and 110th western meridians. South of it are North Dakota and Montana; east of it is Manitoba; west of it is Alberta; and north of it are the unorganized Northwest Territories. Its population in 1916 was about 630,000. Its greatest length is 760 miles, its average width is about 320 miles, and its area is 250,650 square miles, of which 155,092,480 acres is land surface; but of this less than 11,000,000 acres was under crops in 1916.

Saskatchewan has established a record for wheat growing, and among its other valuable products are oats, barley, flax, grasses, roots, vegetables, livestock, poultry, dairying, lignite coal, timber, clay, and shale.

Alberta is the most western of the Prairie Provinces. Its southern boundary is Montana; its western boundary runs along the crest of the Rocky Mountains to a point on about the same parallel as Edmonton, then leaves the mountains and continues due north to the 60th parallel, which is the northern boundary of the province. It covers 255,285 square

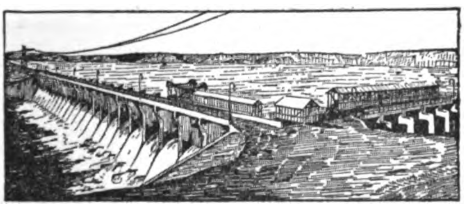


FIG. 143. Modern irrigation is doing wonders in Canada as in the United States. The Bassano dam

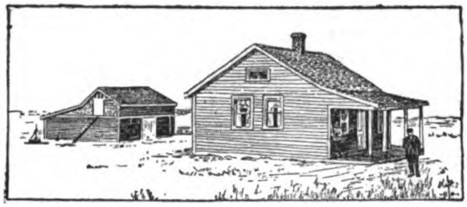


FIG. 144. A ready-made farmstead, as provided for colonists by the government and the railroads

miles, an area greater than that of any country in Europe save Russia; in 1916, it had a population of about 492,000. Of the 161,254,800 acres of land, some 105,000,000 acres are estimated to be fit for agricultural purposes, but less than 4,000,000 acres were in crops in 1916; in other words, only about 4 per cent of the available farm land has as yet been brought under the plow.

None of the other Prairie Provinces presents the variety of features to be found in Alberta. The land surface ranges from vast, level, treeless plains to the wildest mountains. The climate of the southern and southwestern portions of the province is almost the mildest in all Canada; in the district lying southward from Calgary the snowfall is so limited that sleighs are seldom used.

British Columbia. British Columbia contains about 355,855 square miles and 393,000 population. It is traversed from north to south by four principal mountain ranges—the Rocky and Selkirk ranges in the east, and the Coast and Vancouver ranges in the west. There is a coast line of some 1,000 miles, with many fine harbors from which ocean lines carry merchandise and passengers to all parts of the world. Vancouver Island, especially, is building up an immense shipping trade to all parts of the world. It is tremendously rich in timber and minerals, Vancouver Island coal being the highest grade available on the Pacific Coast. The nearby seas are developing large fisheries.

The agricultural area of this province is very limited, but owing to climatic conditions the range of products is extensive, and local market conditions are excellent. The most valuable land is found mostly in narrow mountain valleys, but extensive areas of grazing lands are found on interior plateaus.

The Agriculture of the Provinces

The vast country briefly described above naturally shows enormous variety in soil, climate, and topography, which in the course of time must lead to specialized farming along various lines. In the present stage of development, these factors have hardly been given due consideration by settlers in developing farming systems; the determining factors have rather been market conditions and the trend of settlement. However, Western Canada may be divided agriculturally into six zones according to the types of farming most important in each.

1. **Mixed farming.** The area at present devoted largely to mixed farming and dairying may be said to cover Manitoba, central Saskatchewan, and central Alberta. Parts of Manitoba do not differ greatly from other portions of the Prairie Provinces, but the province includes the oldest settled area and has, consequently, developed mixed farming to a much greater extent. Central Saskatchewan and Alberta are largely covered with poplar groves and brush and in engaging in mixed farming and dairying there the settlers have followed the lines of least resistance. Furthermore, under these conditions the hard wheat, characteristic of the treeless plains, cannot be successfully produced. Each of the three Prairie Provinces has a very aggressive dairying organization and a system of coöperative creameries and marketing is generally followed. Hog raising is practised to a very large extent and poultry adds considerably to the farm revenue. The farmer in these areas is making steady progress, although he has not had the opportunities of "easy money" that has been employed by the straight grain raisers and, in former days, by the rancher. Prosperous homes dot the landscape everywhere and these areas appear to be on a thoroughly sound basis. "Mixed" or diversified farming is, of course, the goal toward which all portions of Western Canada aim. Already it is general all through the country, and it is yearly becoming more widespread. No doubt almost the entire farming operations of that country will some day be on that basis.

2. **Cereal production.** The portion of Western Canada devoted largely to cereal production, frequently with livestock as an adjunct, is located in southeastern Saskatchewan and that portion of southern Alberta lying east of the foothills country. This area also embraces the irrigated section which is dealt with elsewhere (p. 153). The rainfall in this region is somewhat lighter than farther north and east, and the system of farming almost universally followed is summer fallowing. In some parts the land is summer-fallowed once in 3 years; in others the practice of summer fallowing every year is rigidly followed.

Cereal farming, clearly, is not a profitable business on small areas, and the average farm devoted to this system is, therefore, seldom less than 320 acres. In some cases 10,000 to 15,000 acres are embraced within a single farm unit. Mechanical power is very popular, not merely because it has been found more economical than horsepower, but largely because farm help has been scarce and unreliable.

The agricultural problems in this part of Western Canada are the conservation of moisture and the eradication of weeds. Great strides have been made in recent years in dry-land culture, so as to make the most of the rather scanty rainfall. As prices for grain have been on a high level, cereal production has given excellent financial returns where the agricultural practice has been up-to-date and thorough. Because of the light rainfall there is little or no leaching; the lasting quality of the soil is therefore tremendously increased. The practice of summer fallowing and surface cultivation thereafter makes it possible to deal successfully with the weed problems. Stringent laws on this subject are provided and generally are satisfactorily enforced. On the whole the country has been remarkably free from insect pests and fungous diseases. The main crop is wheat, but oats is also largely raised, and barley is becoming more popular. All grain is handled through country elevators

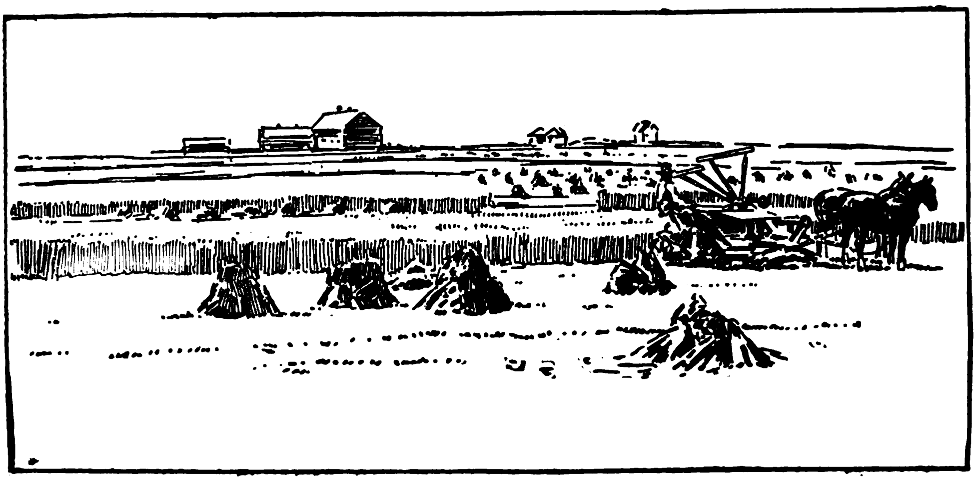


Fig. 145. A prosperous Saskatchewan farm, where grain is the money crop, with livestock as an important supplementary feature

and shipped to lake ports for transfer into ships. Here the grain is very carefully cleaned and treated so that it may reach market in the best possible condition. The system of grading is most complete and is highly organized under the Federal Government. Every car of grain leaving Western Canada is graded at Winnipeg or Calgary and sold on Government certificate. Elevator charges are fixed by law and regulations are laid down regarding car supply and other details. Altogether, the farmers' interests are well safeguarded.

3. **Ranching.** At one time, all southwestern Saskatchewan and southern Alberta was devoted solely to horse, cattle, and sheep ranching. Although a few large herds and flocks may still be found in this region, the ranching district is now confined to the foothills of Alberta, the extreme southwestern part of Saskatchewan and the interior of British Columbia. The "round-up" is becoming a thing of the past. The rancher now generally operates on lands leased from the Federal Government on long terms. Unlike the practice of past years, winter fodder is now generally provided and the same care is given the flocks and herds that obtains in the mixed farming districts (see Animal Husbandry below).

4. **Irrigation farming.** Irrigation has made great strides in southern Alberta, and, to some extent, in western Saskatchewan, during the past 20 years. Irrigation projects in southern Alberta, fully completed or in course of construction, now embrace some 3,500,000 acres of land. The tendency is to lay out farms containing a small area of irrigated land and a larger area of nonirrigated land, so as to make it easier to attain the highest development in feeding and finishing livestock.

The great irrigated crop in Western Canada is undoubtedly alfalfa. Four or 5 tons of hay per acre may be produced, although, owing to the short season, the general practice involves but 2 cuttings. Field peas are also successful but cannot always be depended upon to ripen because of the high elevation and short season. All the cereals give good results under irrigation, but it is questionable whether the higher value of irrigated land for fodder production will ever justify this method of raising them.

In considering the economic side of irrigation in Western Canada, it must first be realized that the foundation of any irrigation enterprise is not the production of fruits, cereals, garden truck, or other expensive crops, but the feeding and finishing of livestock and the development of dairying in all its branches. Thus, the history of irrigation in western United States will doubtless repeat itself in the case of Western Canada.

In spite of the scanty rainfall, livestock finishing and feeding will, of course, be possible on the irrigated lands of this region. It is the expectation that, as ranching develops in

FIG. 146. Irrigated field of sugar beets, showing use of a portable metal dam or diverter

the foothills district of Alberta, and in Saskatchewan, the rough sheep and cattle will be sent to the irrigated sections for feeding and finishing before final marketing. This development is even now being realized and will doubtless become the rule in the future.

The system of irrigation generally practised all through Alberta is "wild flooding." Laterals are laid out along the highest ridges, as far as possible on a uniform slope from the intake to the end. Dams are put in at stated intervals and the water overflows the bank on both sides and seeps through the soil. The larger portion of the irrigated area can be watered very economically, but in some sections considerable expenditure is required on surface work before the water can be profitably distributed. There are very few private ditches. Most of the irrigated lands have been developed by large companies and are being sold at fairly low prices and on long terms.

5. **Fruit growing.** Fruit as a commercial proposition has not, so far, been successful in the Prairie Provinces. The production of standard fruits is confined absolutely to one or two interior valleys in British Columbia, notably the Okanagan Valley and the eastern slopes of the mainland, and of Vancouver Island. The main reliance is placed on apples, pears, plums, and cherries; inland, peaches and apricots are produced successfully. The fruit market for British Columbia is largely located in the 3 Prairie Provinces. There was a great rush into specialized fruit growing in British Columbia some years ago, but the present tendency is to combine fruit growing with dairying and poultry raising.

6. Animal Husbandry

Horses. Because of the growing popularity of the automobile, and because Western

Canada has no convenient market for the highest type of saddle and light draft horses, the breeding of these types has ceased almost entirely there. The popular horse on the Western Canadian farm is the heavy drafter, and Clydes, Shires, Percherons, and Belgians may be found everywhere. Formerly the Clyde horse was the most numerous, but the coming of settlers from the United States has increased interest in the breeding of Percherons. The largest herd of purebred Percheron horses in the world is located in southern Alberta. The climatic and soil conditions of the region are such that horses can be developed to a high state of perfection and at a minimum of cost and risk.

Cattle. In the mixed farming areas, the tendency has been almost entirely to breed dual-purpose cattle. The milking Shorthorn is at present a great favorite and considerable progress has been made in improving the milking qualities of the native cattle, which were almost entirely of the beef type. A number of purebred dairy herds are scattered all through Western Canada, but no great commercial success has been met with in establishing herds of strictly dairy type. A very profitable business is done by the farmers in raising calves for sale as stockers to the cattle operators and ranchers, but, of course, these men require the beef type.

Almost every known breed of beef cattle is represented in Western Canada and some very excellent herds of purebreds may be found all through the country. The Shorthorn leads, with the Hereford a close second; but Galloways and Aberdeen Angus cattle are also very well represented. The beef market lies in Eastern Canada, the United States, and British Columbia. The free entry of beef cattle to the Chicago market has proved a considerable boon to Canadian cattlemen; before this, the Canadian price was fairly well regulated by the Chicago price, less the import duty into the United States. The market for dairy products is largely local, but some years a large export business is done to Asia and Great Britain.

Sheep. Sheep production in Western Canada has been a distinct disappointment. The small flock, although still gaining headway, forms a very small percentage of the present sheep stocks of the country because of the ravages of the coyote and the absence of dog- and coyote-proof fencing on the smaller farms.

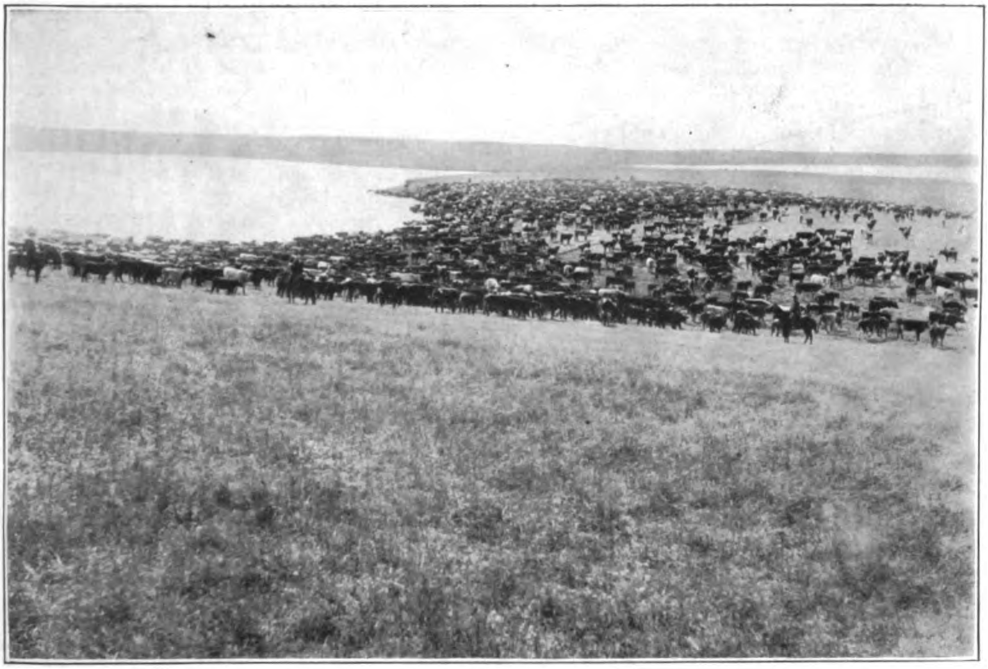
Throughout the southerly part of Saskatchewan and Alberta there are found a good many flocks numbering from 1,500 to 25,000 head, carefully herded day and night. With the high prices for wool and mutton during recent years, the business has been exceedingly profitable. Only in a few cases do the owners of the flocks control the land on which they range. Therefore, as the country becomes more closely settled, it is likely that many of the larger flocks will have to be disposed of.

Nearly all of the sheep in Western Canada are of Merino foundation. They have been crossed with sires of the mutton type, principally the Down breeds, but most of them are not far from the Merino base. Before the removal of the duty upon wool, western flock masters were faced with the necessity of accepting ruinous prices for that product; the result was a gradual shrinkage in the flocks. Access to the United States market has, however, entirely changed the situation, and as long as present conditions prevail it is likely that the sheep business will be profitable. Flockmasters are well organized and the wool clip is generally disposed of on a coöperative basis. The Federal and Provincial Governments assist actively in these public wool sales.

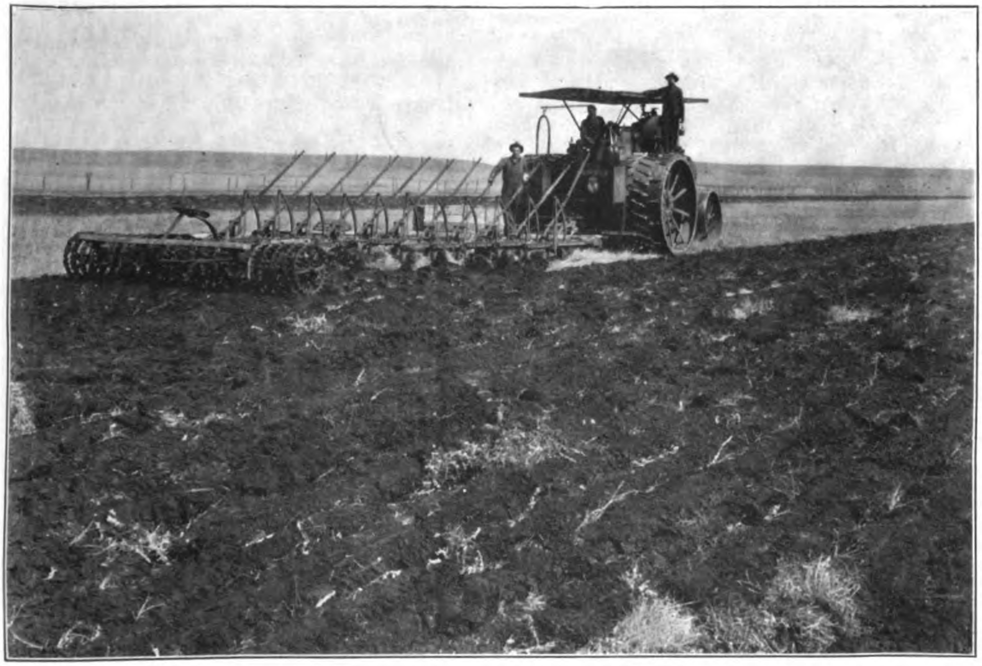
Hogs. Owing to the lack of corn, Western Canada early realized that it would not do to follow the United States practices in hog raising. Attention was, therefore, directed to developing the bacon rather than the lard type of hog, and the agricultural papers and the government have urged farmers to give their attention to Yorkshires, Berkshires, and Tamworths. Nevertheless, American settlers have brought Chester Whites and Duroc-Jerseys into the country, and are meeting with very considerable success.

Several packing houses have been organized in Western Canada, but the bulk of the hogs at present is shipped to Eastern Canada for curing, the product being exported to the British markets.

Hog raising, at the prices that have recently prevailed, has been very profitable; an almost entire absence of contagious diseases among swine has added greatly to its possibilities. In spite of the cold climate the average farmer gets along successfully with very simple shelters often constructed largely of poles and straw. Except where housing facilities are much beyond the average, fall litters are not profitable, nor is their production ordinarily attempted.



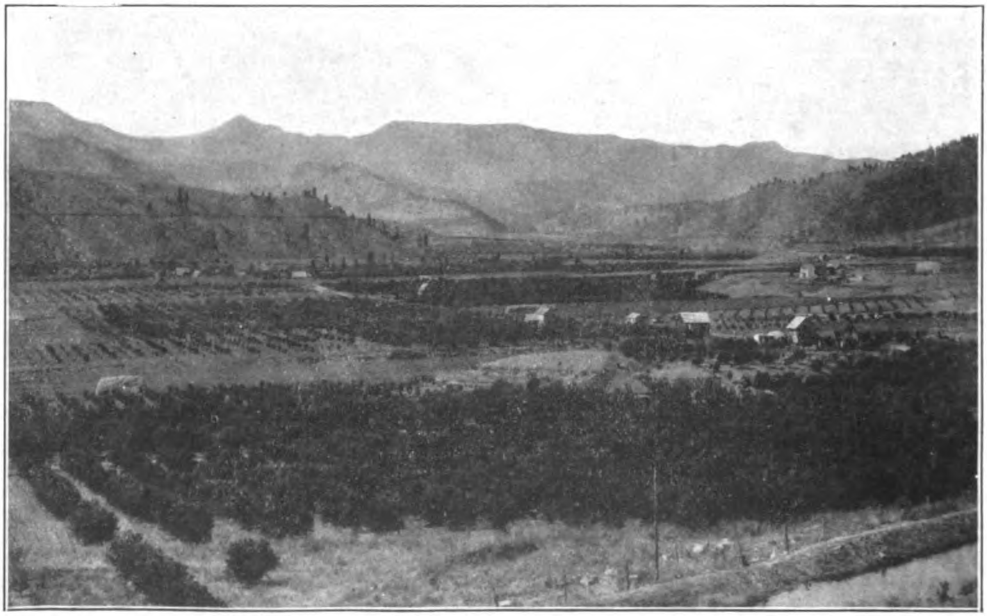
The vast plains of Alberta and Saskatchewan offer some of the finest grazing areas on the continent



On the broad, level prairies of the Northwest the tractor and the gang plow in all their greatness have come into their own (These photos by courtesy Canadian Pacific Railway)

FOR THOSE WHO WANT BIGNESS AND WIDE EXPANSE, THE CANADIAN NORTHWEST HOLDS THE KEY TO A WEALTH OF SATISFACTION AND REWARD

A Missouri farm scene that is typical of almost anywhere within that magnificent stretch of farm country—the "Corn Belt"



A representative fruit growing valley of the Pacific Northwest, whose growers have shown the world how to raise and market fruit

IT IS BECAUSE EACH SECTION HAS ITS SPECIAL ADAPTATION, AND BECAUSE THERE ARE SO MANY SECTIONS, THAT AMERICA IS THE WORLD'S GREATEST FARM COUNTRY

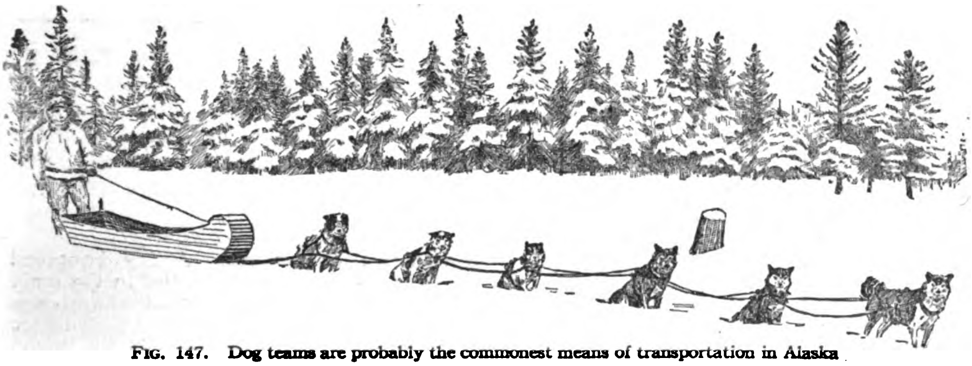


FIG. 147. Dog teams are probably the commonest means of transportation in Alaska

CHAPTER 19

Farming Systems in Outlying United States Territories

ALASKA

ALASKA, ceded by Russia in 1867, is a comparatively new country both in settlement and in geological formation. Although it has 26,000 miles of coast line, or more than the entire mainland of the United States, its area is only about 590,000 square miles, of which the main body lies between latitudes 60 and 70 degrees north, and between longitudes 141 and 166 degrees west.

Surface and soil. Alaska is practically all hilly or mountainous. The Coast Range Mountains, which divide the territory into two rather distinct divisions, the coast region and the interior, are from 5,000 to 6,000 feet high, while the highest peak, Mount St. Elias, is more than 17,000 feet. The Yukon, the largest of 4 large rivers, is navigable for 2,000 miles.

From a crop-producing standpoint most of the soil of Alaska, except where there are silt deposits, is rather poor. This is due to the fact that since the melting of the ice, which covered the surface long after the great glaciers had disappeared from the States, there has not been sufficient time for extensive plant growth and decay as in other older and warmer lands. In many places the soil is very shallow, with gravel near the surface. This leads to rapid drainage so that even where rainfall is abundant crops may suffer from lack of moisture. The soils of the interior, where winters are severe and rainfall light, is especially lacking in humus. Considerable soil is of peat formation. It is estimated that in the entire territory there are about 100,000 square miles fit for tilling or grazing purposes.

Climate. Alaska presents great variations both in climate and in fall of rain and snow. The coast region, made up largely of narrow mainland and islands, has comparatively mild winters, cool summers, and heavy rainfall. At Sitka, on Baranof island, the rainfall averages about 84 inches a year. Here the temperature rarely rises to more than 85 degrees in summer or drops much below zero in winter. There is not much frost after May 1 or before October 1. At Ketchikan, an extremely southern point in the coast region, the average annual precipitation is about 160 inches, while at Orca it is slightly more. Outside of the coast region conditions are very different. At Nome, away up close to Bering Strait, the average annual precipitation is slightly less than 14 inches. The highest summer temperature is 78 degrees and the lowest winter figure 38 degrees

below zero. Throughout the interior the winters are severe, with warm summers and light rainfall. Temperatures of 70 below zero have been recorded and in summer the 95 mark has been reached. Killing frosts may occur any time after August 15. Snowfall varies greatly. Where heaviest, as in the Prince William Sound country, it frequently amounts to 10 feet or more during the winter. Elsewhere, as at Sitka, there are winters when less than a foot of snow covers the ground at one time.

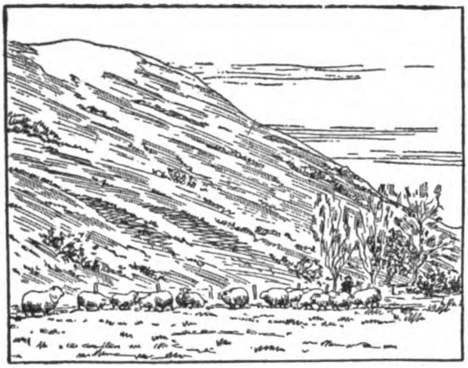


FIG. 148. Sheep on the Agricultural Experiment Station at Kodiak

As the settler finds it. In 1910 Alaska had a population of 64,356—whites 36,347; Indians and others 28,009. It is believed that the white population has greatly increased since that time, while there has probably been a falling off in the number of Indians. There is much heavy timber of spruce, hemlock, cedar, pine, birch, cottonwood, quaking aspen, and other species. Some trees are 24 inches in diameter, but most of them measure less than 12. Northward and toward the interior the trees are shorter and smaller than along the coast. Moss of many kinds is found in the timber regions and in the open up to the snowline. Willow thickets border some of the lower water courses. Large natural meadows of bluetop and other grasses are not uncommon. Good pasturage for livestock is found on the Aleutian Islands and on the shores of Bering Sea. Sedge covers much of the boggy land. Wild berries, including huckleberry, salmonberry, currants, and cranberries abound. Wild strawberries are abundant in many parts of the coast country. Many trees have large slow-rotting roots and clearing is a big job, but the work is less difficult in the interior valleys than along the coast. Grass, rather than timber, covers the western half of the coast region. Far in the interior the vegetable growth is generally stunted. Where grass and other undergrowth is most dense burning is often resorted to, but not always with success.

Markets and transportation. In 1917 there were 6 railroads in Alaska. The fact that most rivers are open only during the warmer months makes them of limited value for transportation purposes. A few improved roads lead into the interior, but in the main the trails are narrow. Dog teams are common. With the completion of projected lines and the building of more and better wagon roads the country will naturally prove more attractive to settlers and the high cost of transportation will be reduced more or less.

The public land offices of Alaska are located at Juneau, Fairbanks, and Nome. Farms can be acquired in two ways: by homesteading under the homestead laws which have been made to apply to Alaska, or by means of soldiers' additional homestead script. Persons qualified to take up land under the general public-land laws may homestead 320 acres of land in Alaska, except land located within a National Forest when they are limited to 160 acres. Mineral land cannot be taken up for farming purposes under the homestead law.

Settlers of the hardy pioneer class, among them many Scandinavians, are pushing their way into the more favored agricultural regions. Log cabins, often with birch bark roofs, are built in the clearings, which are surrounded by pole fences. Alaska has three classes of schools: Schools in incorporated towns; country schools for white children and children of mixed blood; and schools for natives.

The salmon canneries represent an important industry of the coast country, the output amounting to about $15,000,000, annually. Game is plentiful, but hunting laws are more stringent than formerly.

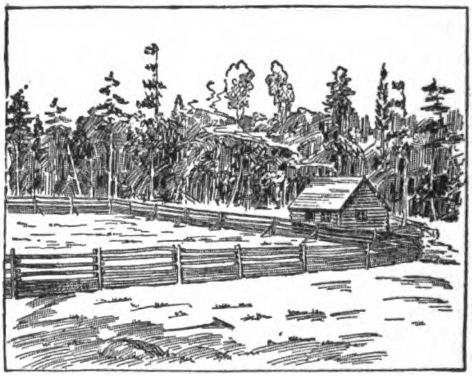


FIG. 149. One of the first steps in settling an Alaskan homestead is the building of a vermin-tight fence around the tilled land.

Agriculture

Crops and livestock. Hardy grain crops, most of the cultivated grasses, and practically all of the cultivated root crops can be grown in parts of Alaska.

In the interior corn cannot be grown. Conditions are not adapted to wheat growing, but it is possible to mature a crop in favorable seasons of ample snowfall. Winter rye will frequently survive when wheat is killed. Oats can be grown in parts of the territory and in normal seasons in all the agricultural districts, early varieties of barley can be matured.

In the coast region the great difficulty in growing grain crops is in harvesting because of the prolonged rainy and usually cool season which prevents the grain from drying out. Grasses and clovers make rapid growth and root crops of all kinds do well. Growing crops for silage will, doubtless, come to be an important branch of farming. Vegetables are successfully grown and with changed living conditions and larger permanent city populations, there will come a more stable and profitable market for truck.

The 1910 census places the number of farms in Alaska at 222. The land in these farms includes 42,544 acres, only 2,660 acres of which are improved. Most of the cultivated fields are really only small "patches." The average value of a farm in 1910 was $6,614, the average value per acre of land in farms, $10.93, and the average value of land and buildings per acre, $20.39.

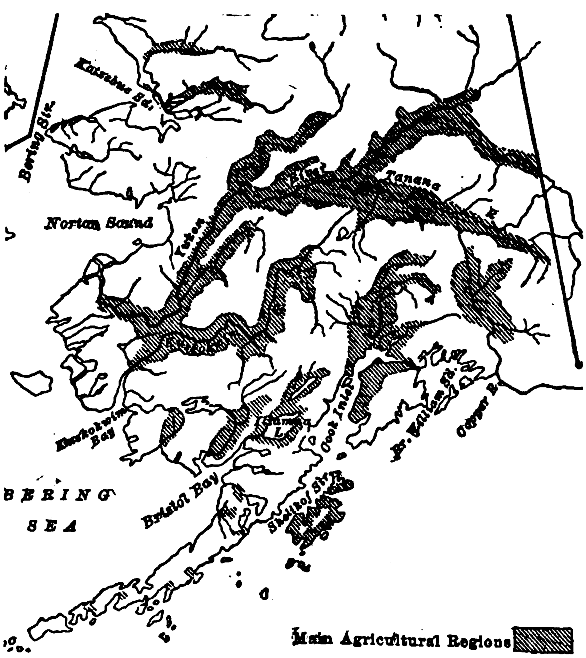


FIG. 150. Map of Alaska showing, by shading, the main farming sections. Note how these follow the rivers, the main lines of transportation and development.

Domestic animals on Alaska farms in 1910 were reported as follows: Cattle, 811; horses, 206; mules, 9; asses and burros, 3; swine, 165; sheep, 184; goats, 36; reindeer, 16,566; dogs used as work animals, 162. There are also many domestic animals "not on farms," that is, in towns or villages. These include 19,795 dogs used as work animals. Reindeer rank second in number and third in value. The total value of all domestic animals in Alaska in 1910 was $1,883,000. Cattle have been kept in favored parts of Alaska ever since Russians were owners of the country, but through inbreeding and lack of proper selection the herds have deteriorated. Galloway cattle have been bred at the Kenai Experiment Station since 1905 and seem admirably adapted to climatic conditions of the region. Sheep of the long-wool breeds do best. In southwestern Alaska the brown bear is a menace to stock raising, but in time this difficulty will be overcome. While Alaska has generally been thought of as a mining region, there are opportunities in farming and especially in livestock husbandry.

THE CANAL ZONE

THE building of the Isthmian Canal by the United States led to the establishment of the Canal Zone, a strip of land 10 miles wide (extending 5 miles on each side of the Canal) and about 45 miles in length. The Zone, ceded by Panama in 1904, follows the line of the Canal. It crosses the Isthmus of Panama in a southeasterly direction from the Caribbean Sea, which opens into the Atlantic, to the Bay of Panama, on the Pacific side. The location is entirely in the Torrid Zone, between 8 and 10 degrees North latitude. The total area is about 450

square miles, but of this probably 25 per cent is taken up by artificial lakes, reservoir watersheds, canal dumps, and land devoted to other purposes, so that probably not more than 325 square miles are left for agriculture. Colon, on the Atlantic side, and Panama, on the Pacific side, are the leading cities.

FIG. 151. Typical shack garden and its owner. The machete in his hand and the pointed stick beside him are his only garden tools.

Soils. The soils of the Canal Zone range from fine beach sand, alluvial and clay loams, to heavy clays of which 10 types are recognized. The soils available for agricultural uses are nearly all red clays. Much of the Zone is very hilly. This is especially true of the southern half where the upper slopes of the hills are so steep that only the lower lands can be plowed for cultivation. The four main divisions, from an agricultural standpoint, are: (1) The low, flat coast fringes and the low alluvial bottoms lying along the streams; (2) narrow strips of flat bottom lands lying largely above Gatun Lake level; (3) lower hill slopes gently rolling or made up of low hills; (4) steep hills.

The Canal Zone soil has two marked qualities: it does not erode or " wash " as do most soils, and there is but little vegetable mold on the surface. The rapid disappearance of decayed vegetable matter is due to the high humidity of the rainy season and to the wind action of the warm, dry season. The fact that there is no freezing, that the heavy clay soils contain but little sand, and that there is a dense vegetable growth with but little cultivation accounts for the resistance to soil washing. When exposed to the direct rays of the sun, all the Canal Zone soils, with the exception of the coastal sands, harden and crack. If plowed when wet they run together and " puddle " badly.

Climate. The Canal Zone climate is typical of the tropics. The range of temperature is but slight, but as to rainfall, there are really two seasons: a dry season extending through January, February, and March, and a wet season from April to December. These dates are not exact, for the dry season often begins about the middle of December, and there are sometimes heavy rains, especialy on the Atlantic Coast, during the dry season. During the rainy season, which is marked by many showers, drizzling rains, and heavy fogs, there are also great downpours, as much as 5.87 inches of rain having fallen in one hour, and 10.48 inches in one day. The annual rainfall ranges from 70.19 inches at Ancón on the Pacific or " dry " coast to 91.85 inches at Gamboa, in the interior and 128.12 inches at Cristobal, on the Caribbean Sea. The mean annual temperature is about 80 degrees F., the average daily range 72 to 86 degrees F., and the extreme range 68 to 97 degrees F. Naturally, the humidity is very high during the rainy seasons.

Agriculture

Crops and livestock. Notwithstanding the fact that travel has made its way across the Isthmus of Panama for 4 centuries, there has been but little agricultural development, and farming is carried on in a primitive manner. Wherever farming is carried on it is in a small way, the cultivated areas averaging but 2 or 3 acres. In fact, large farming operations are not practicable, owing to the hilly, broken surface. Staple crops that seem best adapted to meet local conditions are corn, cassava, yams, sugar cane, plantains, bananas, and upland rice. There are also many tropical and subtropical crops, including coffee, pineapples, cocoanuts, cacao, and rubber. In gardens scientifically cared for many

FIG. 152. A corn patch on a hillside near Pedro Miguel. (This and Fig. 151 from Report 95, Office of Secretary, U. S. Dept. of Agr.)

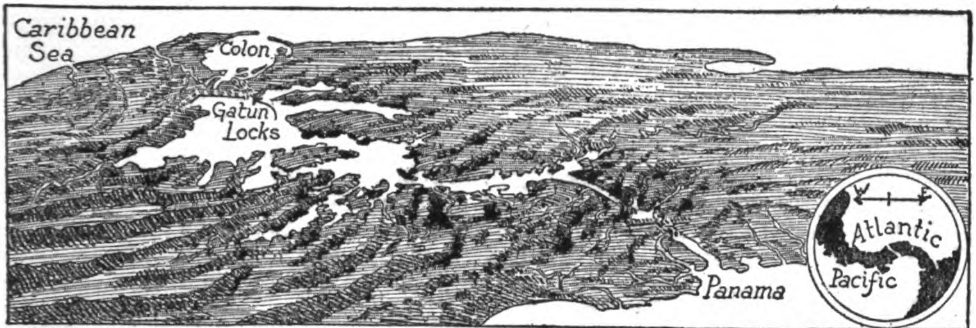


FIG. 153. Relief map of the Canal Zone. The insert explains how the double curve in the Isthmus of Panama gives rise to the strange fact that the Atlantic Ocean end of the Canal is *west* of the Pacific Ocean end

Temperate Zone vegetables including tomatoes, cucumbers, eggplant, lettuce, beans, and carrots, have been grown. Insect pests work great injury to vegetables and ornamental plants. Some gardens owned by Chinese near the population centres have shown the possibilities of the soil when fertilizers are supplied. The growth of vegetation during the rainy season is very heavy. Much of the Canal Zone is covered with a timber growth, including trees of various kinds. There are more than a dozen species of palms. Near the city of Panama is a body of gently rolling land, treeless, and known as the " Savannas." Grazing here is fair. Live stock interests are not large. There are but few hogs or goats in the Canal Zone, while cattle on pasture are greatly troubled with ticks. Guinea grass is relished by stock, and where it thrives there is fair pasture well up into the dry season. Oxen used for draft purposes are fed on chopped stalks of sugar cane, plantain, and banana. There are opportunities for the building up of dairy herds.

The people. With the exception of the military forces, laborers and white settlers who have been attracted by canal and railroad building and by commerce, most of the population is made up of West Indians and others of tropical origin, largely of the Negro race. In the main, the native who is engaged in agriculture is not ambitious and is satisfied to farm a little patch of land. With the coming of a more progressive people, though, progress is noticeable and the possibilities of the country are coming to be appreciated.

HAWAII

THE Hawaiian Islands of which there are 20 (Hawaii being the largest and most important) were annexed to the United States in 1898. They are located in the North Pacific Ocean 2,100 miles south and west from San Francisco. The main islands form a chain extending 390 miles from northwest to southeast, between longitude 154 and 161 degrees west, and latitude 23 and 18 degrees north. Only 9 of the islands are inhabited.

The people. The population of Hawaii, in 1910, was 191,909. While this was a gain of 37,908 for the preceding 10-year period, it was less than half the native population of the territory when discovered by Capt. Cook in 1778. The great falling off which has taken place despite the influx of Americans and Europeans, who went for purposes of trade, and of Chinese, Japanese, Porto Ricans, Portuguese, Spanish, Russians and others, largely laborers, is due to economic changes. Trade and intercourse with the outside world came with the white man. As far back as 1849 sailing vessels carrying foodstuffs for gold seekers made the trip from Hawaii to the California coast. Whaling fleets were also supplied.

Development. At present much of the farming is done on a big scale and represents large investments of capital. Many of the natives have ceased to be farmers, partly because much of the land has been taken over by corporations for the production of sugar cane, and for plantations of pineapple, sisal and other crops. Not only did the growing importance of the sugar industry tend to dis-

courage farming in a small way, but early homestead laws, providing for only a few acres, had much the same effect. Market conditions also discouraged the small farmer. Shipping charges on small quantities of products were very high, nor were there any established grades or reliable local markets. Furthermore, transportation companies taking sugar to the mainland sought to have a large return freight, so hauled back much farm produce, thus checking local farming enterprises. More recently, especially from 1900 to 1910, which covers the period since the organization of the territorial government and the extension of the American Constitution to Hawaii, there has been a decided change for the better. The old system of contract labor on the sugar plantations was followed by tenancy agreements for hired labor. Another step of far-reaching influence was the establishment, in 1909, of a Territorial market. Through this, a reliable local trade has been built up, modern packing and shipping methods have been introduced, trade with the mainland has been developed, and the necessity for diversified agriculture has been shown. The various languages and races represented have made coöperation doubly difficult, yet results have been satisfactory.

Agriculture is being established on a better basis. Farms in 1910 numbered 4,320, an increase of 2,047 in 10 years. However, this represents only a slight increase in actual agricultural acreage as the average farm contained 599.7 acres in 1910, but 1,148.1 acres in 1900. Of the large plantations more than three-fourths are operated by white farmers, there being an increase of almost 50 per cent between 1900 and 1910. Japanese farmers increased by more than 300 per cent and Chinese farmers by 18 per cent in this time. On the other hand, native Hawaiian farmers decreased in number.

Honolulu, the leading city, had in 1910 a population of 39,305, including a large American colony. Many people of means have been attracted to the city because of the delightful climate.

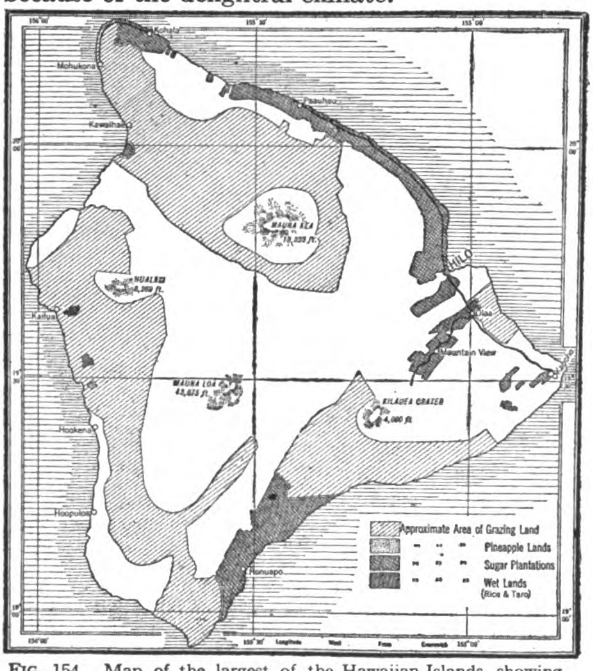


FIG. 154. Map of the largest of the Hawaiian Islands, showing the distribution of areas devoted to special types of farming

Soil, and surface formations. Each island of the Hawaiian group contains one or more mountains or mountain ranges. There are also many gulches and deep ravines. Elsewhere the surface is rolling rather than level. The soil composed largely of basaltic lavas in various stages of decomposition is of comparatively recent formation and represents many unusual types; the manganese soils are unlike any elsewhere. Most of the soils are red; although they contain as much as 50 per cent by weight of particles as fine as clay, they are not true clay soils. The lowlands, containing tracts of deep soil washed down from the mountains by tropical rains, are highly productive. In some small districts are virgin fern soils which, in addition to a high percentage of humus, contain more or less sand and gravel. Of the land as a whole, only a small part has been brought under cultivation. The best of this is in comparatively narrow, irregular strips.

Much of the Hawaiian soil is hard to handle, and the cost of tillage is high. In order to aid

aëration and to provide for water storage deep plowing is often resorted to, but in the heavy clays where the soil sticks to the plow and increases the draft, this is difficult. Where soil is plowed in times of too much moisture it "puddles" badly and is hard to bring back to good tilth. In the more compacted soils the water, especially during heavy downpours, flows swiftly over the surface carrying away much plant food and doing great damage, instead of being stored for use during dry seasons. Ditches to carry off the overflow have been provided in some fields. In contrast with this, in other much more porous soils, the water goes down so rapidly that it is soon below the reach of plants.

Climate and rainfall. The climatic conditions of Hawaii are favorable for agriculture. While summer weather is continual and uniform, the climate in general is warm-temperate rather than subtropical. In the mountains, conditions resemble those of the cooler parts of the Temperate Zone, while at lower altitudes tropical conditions prevail. Trade-winds from the northeast bring rains, and the windward districts have, in general, abundant moisture. Annual rainfall is seldom much below 20 inches and has reached 178 inches with as much as 30 in one month. Irrigation, though costly, is necessary in many places, and great systems of tunnels and pumps have been constructed at immense outlay.

Agriculture

Crops. Owing to its geographical position and range of elevation, it is possible to grow in Hawaii all tropical crops and also nearly all those of the Temperate Zone. Where soil and moisture conditions are most favorable plant growth is very rank. Most of the useful plants grown were introduced from older lands, and those coming from seed had at first but few natural enemies. However, pests have gradually crept in and finding very congenial conditions tend to become very destructive. Cut-worms and other corn enemies have increased since the destruction of the golden plover. The growing of many different crops, instead of a few, is helping in the control of insect pests. The total value of Hawaiian crops in 1909 was $28,536,000, more than nine tenths being represented by sugar cane. From 1899 to 1909 the number of farms reporting sugar cane increased from 184 to 1,028, and the acreage from 65,687 to 186,230. At the time of the Thirteenth Census the only other crop having a value of more than 1 million dollars was rice. Most of the cane is grown on large plantations owned by joint stock companies. Through the planting of improved varieties and with better cultivation it is hoped to increase the acre yield. However, as the new lands taken over by the unirrigated plantations is largely

FIG. 155. Prickly pears (cactus) pasture in Hawaii

on the high levels, where much of the soil is poor and thin, it is hard to bring up the average yield for the entire country. Large amounts of commercial fertilizer are used. One of the biggest problems is that of transportation.

Tropical fruits are highly important. Pineapples valued at $453,000 made up more than two thirds of the value of the 1909 tropical fruit crop. More than 100 species of fruit are successfully grown, but many that thrive in the United States mainland such as blackberries, raspberries, and gooseberries, do not do well in Hawaii. The importance of the pineapple has greatly increased during the last few years, large quantities being now canned and shipped. Papaya, a strictly tropical product, is a favorite breakfast fruit of Hawaii. Taro, grown in watery places, makes up a principal part of the food of the natives. The algaroba tree, which thrives in the drier parts of the country, is a source of firewood, and produces large quantities of sweet nutritious pods used as feed for livestock.

Considerable capital is invested in the growing of sisal hemp, the fiber of which is of excellent quality. The crop is grown on the arid and more stony lands of the leeward districts.

The cultivated forage crops grown in Hawaii include sugar cane, corn, the sorghums, para grass, Guinea grass, Rhodes grass, oats, wheat, barley, millet, teosinte, alfalfa, cowpeas, soy beans, velvet beans, jack beans, peanuts, pigeon peas, horse beans, Canada peas, vetch, cassava, sugar beets, mangel-wurzels, turnips, rape, and spineless cactus. Under the most favorable conditions, alfalfa introduced in 1895 grows very rapidly, making from 10 to 12 cuttings per year; but it is not easily cured for hay. Potatoes, both Irish and sweet, are grown. Most of the corn is shredded and baled and used as roughage for livestock fed on algaroba beans. Several species of leguminous trees, including Koa, Mamani, and Kiawe, grow wild. The leaves of a shrub known as koahaole are eaten by cattle and horses, but are said to cause falling of hair from the manes and tails of the latter. The cactus, supplying both feed and drink, occupies an important place during the dry season. It is said that in Hawaii there are cattle 3 or 4 years old that do not know the taste of water.

Livestock. Grazing is important in the rougher sections not suited to cultivation, but there is a shortage of grass on nearly all ranches during the summer months. Buffalo grass grows well, forming a dense mat and supplying an abundance of feed. Australian, or large water grass, grown for 40 years, is probably the best of the pasture grasses. It grows under varied conditions of soil, moisture and elevation; is easily established, either from seed or division of the roots; survives overstocking and drought; is relished by stock; and is rich in feeding value.

Wild cattle and goats are still found in the rougher regions, although many have been killed. Gradually, however, Hawaiian livestock of all kinds is being improved. The development of the sugar industry made an immediate demand for domestic animals for draught purposes and for meat. This has led to the importation of purebred stock, the introduction of tame grasses and other forage plants, and the destruction of harmful grasses and weeds.

The value of Hawaiian livestock, in 1909, was $4,407,000. Cattle numbered 145,029: horses, 15,856; mules, 7,956; asses and burros, 1,756; swine, 20,484; sheep, 76,710; goats, 4,451, and carabaos, 399. Wool and hides are exported, but the supply of butter and cheese falls far short of the local demand. Hawaiian fowls numbered 95,667 in 1909; the smaller and thinner-feathered breeds do well if kept free from disease.

PORTO RICO

THE island of Porto Rico, oblong in shape, about 36 miles from north to south and 100 miles from east to west, is the farthest east of the Greater Antilles. It lies between 65 and 68 degrees west longitude and 18 and 18½ degrees north latitude, and is about 1,500 miles east of New Orleans.

Surface and soil. The greater part of Porto Rico is rough and broken, yet the highest elevations are only about 3,000 feet. The main range of mountains extends from east to west. Of the 3,600 miles making up the total area, about one tenth consists of islands bordered by low lands of greater or less extent. Inland there are many deep and narrow valleys. Much of the soil of Porto Rico has been formed by the decay of volcanic rock like that forming the backbone of the island, yet the soil varies greatly. In respect to area, red clay is one of the principal soils. Foothill soils, bordering the plains, are dark in color. The soil of the mangrove swamps contain coral sand with some organic matter. Near the seacoast there is much coral sand. Most of the rocks of Porto Rico are limestone, but there is some granite, marble, and sandstone. Practically all of the island was once heavily timbered, but most of the timber has been removed.

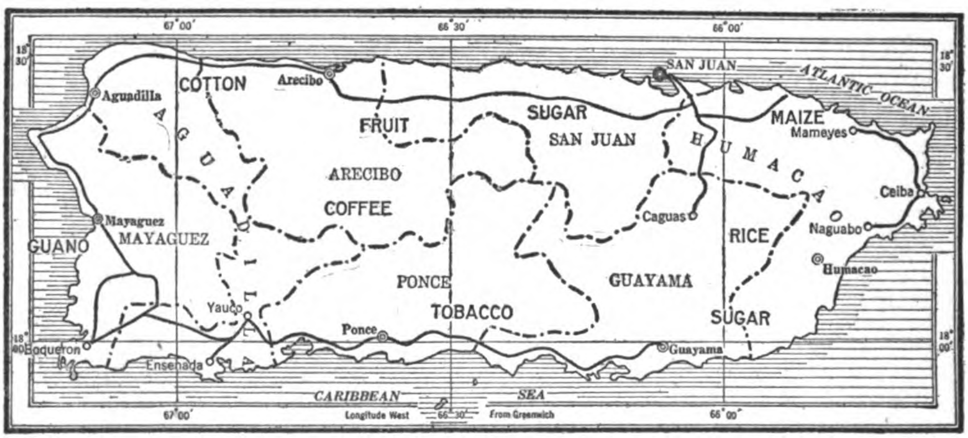


FIG. 156. Map of Porto Rico showing political divisions and main sources of important agricultural products. (Doubleday, Page & Company's Geographical Manual and New Atlas)

FIG. 157. Windbreak of bananas (*at left*) protecting a citrus orchard

Climate and rainfall. The climate of Porto Rico is generally uniform and, although the humidity is rather high, is delightful throughout most of the year. The mean annual temperature is about 78 degrees, while the winter months average about 70. Summers are not oppressive and there is generally a good breeze. Prevailing winds are from the northeast. The mornings are likely to be clear with showers in the afternoon. Very heavy downpours are not uncommon, from 10 to 12 inches of rain sometimes falling in 24 hours. Winter months are drier than summer. The annual rainfall ranges from 150 to 40 inches.

The people. Porto Rico, acquired by the United States in 1898, is thickly settled with a mixed population. In 1910 the census showed 1,118,012 people, a gain of 17.3 per cent in 10 years. Labor is plentiful and cheap. On the whole, the people are more progressive than in many other tropical islands. There are railroads and two or more well-built macadamized roads. The cities of San Juan and Ponce have electric roads.

Agriculture

Farms and crops. In 1910, Porto Rico had 58,371 farms, embracing 2,085,162 acres, three fourths of this being classed as improved land. Average size of farms is 35.7 acres. All farm property, including land, buildings, implements, machinery, and livestock is valued at $102,379,000, just a little less than three fourths being invested in land. The average value of a farm is given as $1,754. Of the farms listed in the Thirteenth Census 44,521 are operated by white farmers, and 13,850 by colored farmers. Only 2 per cent of the farms are operated by managers, yet these farms average 343.4 acres, about 11 times as great as that operated by owners, and considerably larger than that operated by tenants (21.7 acres). The average size of farms operated by white farmers (42.2 acres) was nearly three times as large as that of colored farmers (14.7 acres). Of farms of less than 5 acres there are 20,650, yet there are 207 farms of 1,000 acres or more.

In 1909, the value of all crops of Porto Rico was $25,559,265, sugar cane, the leading crop of the lowlands, making up slightly more than half of the total. Cane was grown on 6,816 farms, and from 145,433 acres the harvest was 3,087,612 tons. With better seed, improved methods, and modern machinery this crop is proving profitable. Coffee was grown on 25,433 farms and 186,875 acres the yield being 52,717,727 pounds, valued at $5,292,179. Another staple crop is tobacco, grown on 8,329 farms in 1909. The yield from 22,142 acres was 10,827,755 pounds valued at $1,938,092. The value of all fruits and nuts grown in 1909 was $2,293,532, more than two fifths being represented by bananas. The value of all vegetables was placed at $1,214,310.

It was at one time believed that vegetables could not be successfully grown in Porto Rico, but now at the agricultural experiment station at Mayaguez, as well as elsewhere on the island, vegetables of the Temperate Zone are being grown from good seed and with proper cultivation. One cause for early failures was that most Porto Rican homes are on the hills where conditions for vegetable growing are less favorable than in the valleys. Very heavy downpours together with plant diseases, due to long rainy spells, have also proved hindrances. The uplands of the island are well adapted to coffee growing, but there is need of improved varieties, especially suited to American tastes. Coffee land, in 1909, was valued at from $5 to $50 per acre, and sugar land at from $100 to $200 per acre.

The citrus fruit industry, which has been developed mainly during the last 20 years, is making rapid growth. There is no danger from frost, and New York, one of the best of markets, is easily reached. Pineapples and many other tropical crops are grown. The avocado, or alligator pear, and the native mango are found in all parts of the island. Bananas also grow in most parts, and cocoanuts along the sea coast. There is considerable trouble from plant diseases and insect pests. More cover crops, such as cowpeas,

FIG. 158. Cloth covered tobacco fields in Porto Rico

jack beans, sword beans, Lyon beans, and Florida velvet beans, are greatly needed to improve soil conditions, to band together the sandy soils, and to loosen the heavy clays.

Livestock of all classes was valued in 1910 at $10,947,000, there being 313,886 cattle valued at $26.45 per head; 55,225 horses, worth $30.89 each; 4,569 mules, 985 asses and burros, 103,041 swine, 5,525 sheep, and 45,982 goats. Cattle and swine are found on more than half the farms; horses on almost half, goats on one third, and sheep on only about one per cent. Sheep, except an African breed, have been affected with scab. The poultry industry has been hampered by the high price of feed. In cattle breeding, work has been done in crossing Zebu blood on native cattle, in the hope of increasing the working value of the ox under Porto Rican conditions. Much of the livestock now on the island is descended from animals brought in by the early Spaniards and is very inferior. With the introduction of better blood, livestock raising is sure to prove more profitable, but horticulture will probably continue to be the leading agricultural industry.

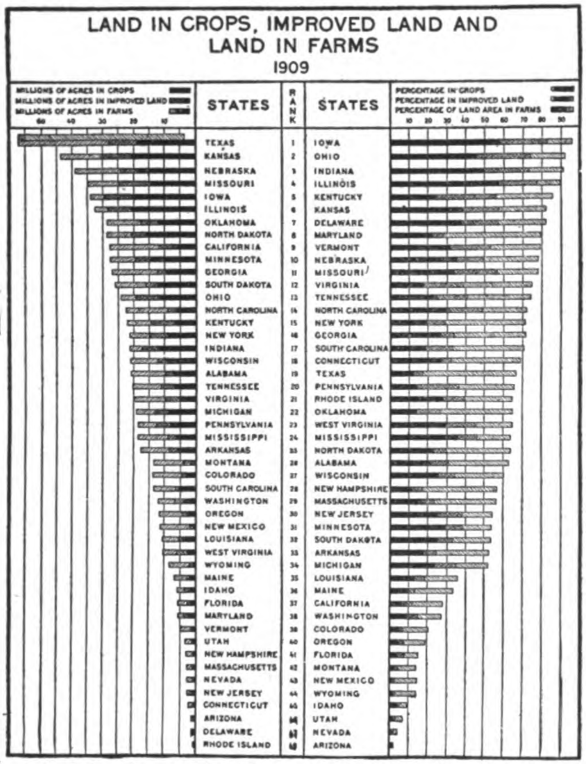


FIG. 159. The ranking of the states in relation to crops, improved land and farm land, according to the 1915 Yearbook of the U. S. Dept. of Agriculture. Study this in connection with Figs. 97 and 216.

FIG. 160. The combination of several crops—some to be sold and some to be fed—with one or more kinds of livestock, is "doubtless the most desirable type of general farming"

CHAPTER 20

The Principles of General Farming

By EDWARD VAN ALSTYNE, *late Director New York State Farmers' Institutes and practical farmer from* 1876 *to* 1918. *His farming was typical of the subject he discusses since it included the production of fruit, grain, and hay as money crops, dairying, and sheep and swine raising. He gave attention to Institute work from* 1889 *until his death and always took an active and effective interest in the agricultural, horticultural, and dairy affairs of his state.*—EDITOR.

BY **general farming**, we mean the raising of several crops with or without livestock, in contrast to **specialized farming** in which practically all the land and energies are devoted to one or at most two crops. In a sense, the man who devotes his farm solely to some form of stockkeeping is a special—not a general—farmer. However, the need of growing part or all of the feed for his stock makes his business more general than that of the fruit grower or market gardener.

Livestock and Crops

Such a combination is doubtless the most desirable type of general farming. The stock, if of the right type, and intelligently fed and cared for, helps to maintain and increase fertility in the most economical way; and no farmer is really successful who allows his soil fertility to decline. Fertility thus returned to the soil through the animal should cost nothing, and should be in addition to whatever cash profit is obtained from the proper marketing of the animal's products. Often, too, there is no way to market certain crops, such as pasture and corn stalks, except through the animal machine. Perhaps there is no finer example of the combination of livestock and a crop than that of corn and hogs, as found on a majority of corn belt farms.

The more nearly a farm sustains its stock without having to purchase feed, the better. Therefore it is desirable to raise a variety of feed crops; and this brings into profitable use several types of soil and helps provide steady work for men and teams. Two kinds of stock may often be kept; dairy cows and swine combine well, particularly where the skimmilk is kept on the farm. Purebred animals mean increased profits from sales, but they also require more knowledge and skill and a heavier investment than grades. On the whole, no type of farming tends to develop the farmer more than this crop and stock combination. He is dealing with both plant and animal life; he must know something of breeding as well as of feeding; he must understand soils, fertilizers, insect pests, and plant diseases; he must know the principles of trade and business; and he must be a manager of men and things.

Hay for market is a good crop to combine with livestock in some sections, such as New England and New York, parts of the middle western alfalfa belt, and portions of the South. It requires the least possible cultivation; it is harvested when stock and other crops need little attention; and it may be marketed whenever convenient. Sometimes a combination of hay and wheat or rye goes well with stock. The animals need the straw; the grass can be seeded with the grain; and any hay not needed for feeding can usually be marketed without trouble and at a good price. This is particularly true of timothy, which is of least feeding but highest market value. In the South corn, cowpeas, and cotton make a fine

trio with which livestock is being combined to a constantly increasing extent.

Livestock and potatoes form another good combination, although this crop is more exacting and more uncertain than hay or grain. Beans and cabbage often work in well on the stock farm. Bean fodder can be used by either cows or sheep, and unsalable cabbage is as valuable as silage, although it must be fed with great care lest it taint the milk. Orcharding and livestock sometimes go together for corn, and leguminous plants may be grown between the young trees. The stock requires labor the year around, but for the most part early and late in the day, thus leaving the men free when they can best be used in the orchard.

Combining Different Crops

One must always keep in mind the adaptability of crops to soils and markets, and also their planting and harvesting seasons with relation to other farm work. Heavy clay is not suited to potatoes but makes excellent grass and grain land. With both heavy and loamy soil on his farm one may well raise some of each. Corn and potatoes in large quantities rarely go well together, since both must be planted at about the same time and cultivated well into the summer. Beans and corn are a much better combination, for the beans should not be planted until after the corn is in; yet to a considerable extent the cultivation of both will come at the same time, and sometimes the harvesting. If there is much haying or other midsummer harvesting to be done the cultivating of such crops as corn, beans, and potatoes is often neglected. One should have this fact in mind before planting too heavily of either.

With the above limitations, winter grain fits in well with cultivated crops. The land for it is plowed and fitted after harvest when teams would otherwise be idle. The grain is sown before the fall crops are ready to harvest. If grain is to follow beans, early potatoes or silage corn (that have been kept free from weeds) no plowing is necessary and thus the expense is reduced. Also the grain needs no further attention till harvest. Orcharding combines well with any of the above, since corn, beans, or cabbage can occupy the space between growing trees. However, potatoes do not go well with tree fruits; they must be planted just when the orchard needs spraying and tilling; they, too, require considerable spraying; and the time for harvesting the two crops is identical.

FIG. 161. Whether or not this equipment represents overinvestment depends on the size of the farm, the crops grown, the supply of man labor, and a number of other factors. The farmer's accounts should supply the answer

Underlying principles. There should always be a proper rotation of crops. There is no way in which the soil can be so economically supplied with vegetable matter as from a sod plowed under. Corn, beans, and potatoes all do well after sod; and grain does much better after a tilled crop.

Every rotation should include at least one leguminous crop such as clover, vetch, beans, or peas, to utilize nitrogen from the air. Crop residues, such as straw and stubble, help to supply vegetable matter.

A deep-rooted crop like potatoes should be followed by a shallow-rooted one like grain. A heavy feeder on nitrogen, such as corn, would better be followed by one calling for more mineral matter, such as potatoes or grain.

Rotation tends to prevent insects and diseases from becoming established. Potato insects and fungous diseases do not attack corn; the corn root worm does not feed on potatoes; and so on. If rotation is practised, before any one crop is replanted on the same land, some of its enemies will have died out.

In addition to intelligent rotation, desirable factors in general farming are the

economical maintenance of fertility; the steady employment of men and teams; and the profitable use of land with an adequate income.

Where General Farming is Found

General farming is especially adapted to sections where there is a variety of good soils—as in the Middle and Eastern States—and where these soils and the shipping facilities permit the growing and marketing of several types of produce. It is usually carried on within easy railroad distance of large towns, in other words, in the longer settled parts of the country. Milk and cream are most profitably marketed within 50 or at most 400 miles of where they are produced; cheese and butter can be shipped across the continent. Hogs sold dressed to a local dealer bring more per head than a large number sold on the hoof by the carload. Some farms are located within reach of such retail markets; but the large scale method is, of course, the only practicable one for the large grower of the Corn Belt. So, too, with grain (which usually nets more if sold locally), potatoes (which always find ready sale in any town), and most fruits. As long as the supply does not exceed the consuming ability of such a market, nearby selling is most profitable. The grower who can choose between several good markets within a radius of 100 or 200 miles has a decided advantage.

FIG. 162. Too small an equipment is as bad as too large an outfit. This farmer is trying to harvest 30 acres of hay, alone, with one horse and wagon—an unprofitable task.

Formerly the Middle West grew grain almost exclusively. With the improvement of transportation facilities and the growth of nearby towns and cities, general farming is taking its place.

Formerly the South grew but one crop—tobacco, cotton, or corn, neither of which was economically utilized. Decreased production and increased diseases and insects followed, as they always do a one-crop system; even a partial failure then meant disaster and nothing left with which to buy food products outside. To-day general farming is slowly, surely, and wisely making itself popular.

At one time Long Island grew livestock and grain. Since the building of the Erie Canal and, later, the railroads, New York City has been supplied with such staples at a lower price, and the Island is given mostly up to vegetables. The same is true in principle around Boston and, to a lesser degree, many smaller cities.

Factors That Make General Farming Possible

1. **Natural conditions.** Unless both climate and elevation are medium, the season will be too short, with late and early frosts. There should be at least 100 days between killing

FIG. 163. Vegetables and tree fruits may be combined where location, labor conditions, and markets are favorable

FIG. 164. Only valuable products can profitably be hauled long distances. A $65 load of bluegrass seed

FIG. 165. Undercapitalization in buildings is sometimes necessary, but never desirable

frosts and 120 is much safer except for a few hardy crops. There must be enough rainfall; at least 25 inches, well distributed throughout the growing season, is necessary for good crops. The distribution is almost as important as the amount. The land must be reasonably level or it cannot be economically worked with labor-saving tools. It should be naturally productive; soil made rich artificially is expensive to handle.

2. **Location, markets, transportation.** It is seldom wise to engage in a line of farming not generally practised in the neighborhood. The available farm hands rarely know how to grow or handle a new crop. Probably conditions are not favorable, or it would have been grown successfully before; the practices of a community are usually based on, and the result of, experience. Proper machinery is often not available, as, for instance, a separator that will thresh rye straw unbroken so that it can be sold at the highest price; or a special puller or harvester for handling beans if either of these crops is to be grown profitably.

Unless the farmer has a special market of his own (which is not often the case) a crop is more difficult to market if not generally grown. A quantity creates a demand and invites competition.

General farming cannot usually be carried on profitably more than 8 miles from market. Even at this distance, bulky crops like potatoes and hay are seldom profitable when the hauling must be done by team unless the farm is located on a good, hard-surfaced road on which large loads can be hauled or a motor truck used practically throughout the year. Location on a railroad line reaching nearby cities within a few hours gives the farmer a choice of markets. Speed, proper handling and delivery, and reasonable rates for farm products, are very important features of any transportation system. Such transportation or the lack of it is a determining factor in choosing crops.

3. **Land values.** One can seldom afford to grow low-priced crops on high-priced land. Land lying near a residential section is usually too valuable for any but the most highly specialized farming; otherwise, the richer, more productive lands are really cheaper than the low-priced ones. The real value of land is its producing power.

4. **Capital.** No amount of money will ever take the place of actual farm experience. Good farms in the hands of inexperienced men with ample capital are probably more often unprofitable than any other kind except, perhaps, farms on very poor land. Nor will theoretical knowledge ever take the place of actual experience. On the other hand, many an inexperienced, industrious man has failed because of lack of capital. The amount necessary has doubled since 1850 as the following table from Dr. G. F. Warren's "Farm Management" shows:

AVERAGE VALUE OF FARM PROPERTY PER FARM IN THE UNITED STATES

YEAR	REAL ESTATE	IMPLEMENTS AND MACHINERY	LIVE STOCK	TOTAL
1850	$2,258	$105	$376	$2,739
1860	3,251	120	533	3,904
1870	2,799	102	462	3,366
1880	2,544	101	393	3,038
1890	2,909	108	506	3,523
1900	2,905	133	536	3,574
1910	5,471	199	774	6,444

At the present time the figure for real estate is still greater by a quarter or about $6,700; that for implements is a third higher or about $250; and that for livestock nearly if not quite half as great again or around $1,100. Overhead charges are substantially the same whether on a large or a small farm—a rich or a poor one. But the producing power of the rich farm is much greater. If livestock is kept, the capital invested in it may be from an eighth to a quarter of that invested in land and buildings. There should always be, if possible, a working capital of from a few hundred to $1,000. One can always buy cheaper for cash, and labor should be paid promptly.

5. **Equipment.** In establishing a system of mixed farming, care should be taken that the

FIG. 166. A substantial, well-kept set of buildings on a good-sized, productive New York State farm

lines chosen are not so many or so unrelated as to require too large an outlay for machinery. A drill will sow both spring and fall grains and grass seed, and plant beans and corn as well. It rarely pays to put $150 in a binder to cut 10 or 15 acres of grain.

Where most of the farmers in a section are following the same line, it is usually possible to hire expensive machinery; especially if the farmer is systematic in his work and pays promptly. This is often more profitable than owning it, since less capital is required and nothing has to be charged up for depreciation or repairs. Of course it may sometimes prove impossible to get a machine at exactly the time when it is most needed. It never pays to keep horses for a year when they are able to do only 6 months' work or less.

Some Features of General Farming

1. **The land.** Soil best suited to general farming is deep, rich in mineral matter and also in vegetable material. Prairie soils are deep but usually lacking in minerals; glacial soils (p. 8) usually contain plenty of mineral matter, but some typical forms, such as sands and mountain soils, are often shallow or otherwise unsuited to most crops.

Heavy clays if well drained are among the most productive soils, but they are rather difficult to handle and are not suitable for most fruits. Bottom land is fine for grass and corn and needs less added fertilizer than upland types. Gravels and sand will not stand drought but are satisfactory in wet seasons. Stony soils may be productive but they are hard to work. Muck is well adapted to certain vegetables and when potash and other minerals are supplied potatoes grow well on it. Some mucks are rich in lime and on these clover flourishes. In general limestone soils are the strongest of all and among the most desirable, if free from stone.

FIG. 167. This represents overcapitalization in buildings. Though common on country estates (where the owners can doubtless afford it) it is a serious obstacle to the success of a practical farm

2. **Buildings: type and number.** These must fit local conditions and the farm activities. On many general farms, buildings that were erected when lumber was abundant and cheap are usually spread over too much ground, inconvenient and expensive to keep in repair. Barns should not be too far from the house, and it is preferable that they should be in the background. There should be as little roof surface as possible; this means 2 or 3 stories and high posts (see Vol. III for desirable features in barn construction).

Stock growing needs a somewhat different type of building from those on a grain farm, yet the two types may readily be combined. The accommodations for stock on the general farm should never cost more than $50 per each 1,000 pounds of animal; in the South and under range conditions this limit should be greatly reduced. The silo should hold the bulk of the roughage.

The dwelling, while part of the farm equipment, is also the home, and no pains should be spared to make it attractive, comfortable, and convenient. But not more than 10 to 20 per cent of the capital should be invested in it. The old-time farmhouse can be equipped with light, heat, and water at a moderate expense. New ones should be farm homes, particularly suited to the convenience and comfort of the farmer and his family, and should never be patterned after the city house or rural bungalow.

3. **Marketing.** While no man can expect to excel as producer and salesman too, the average general farmer, especially the small farmer, must be both. It is expensive to market small quantities even over short distances. The man who drives a couple of miles with a can or two of milk or a crate of berries is marketing in a costly way. The much talked of "selling-direct-to-the-consumer" is a small business and has many disadvantages. Wholesale selling saves many little expenses and much annoyance, and may be actually more profitable.

Coöperation offers certain advantages but to be effective it must involve standardization of products and expert, well-paid management. The first essential in marketing is a well-grown, first-class article, well graded and honestly packed, which will usually find a ready sale at top quotations or above.

4. **The income.** One should aim to organize his business so that his income will cover ordinary expenses (including interest and upkeep), enable him to live well, and allow him a salary for his work proportionate to his investment and the amount of time and energy he put into his business. This means that there must be a liberal margin, for not every crop will be profitable. It is a good plan, if possible, to let one crop take care of interest, another the labor cost, another the upkeep, another a sinking fund or profit, etc.; sometimes one crop can look out for more than one such expense item. A distinct advantage of dairy and poultry activities on any farm is that each means a regular income, monthly or even oftener. A variety of crops usually provides an income spread over a good part of the year.

5. **The outgo.** Aside from certain fixed charges—interest, taxes, insurance, etc.—there will be as much variation in outgo as in receipts. Repairs to buildings sometimes multiply rapidly; machinery may give out sooner than was expected; livestock die or become useless all too soon. One should never estimate on the basis of figures for income or outgo unless they are averages for a number of years. Sometimes poor crops or low prices and heavy expenses occur in the same year; occasionally the reverse is true. There are times when the farmer must keep his head and avoid giving way to either despair or unwarranted optimism.

If funds from sales of produce are insufficient to meet expenses as they come due, it will always pay to borrow money so as to pay cash. Usually much more than the interest will be saved by so doing and a man buys more carefully than when he has—apparently—unlimited credit.

6. **It distributes the risk.** This is one great advantage of mixed farming. Rarely will any one year find every crop a failure, or prices low for all of them. Outbreaks of destructive plant and animal disease, insects, flood, drought, other kinds of damage—all are sure to come, as well as over production of certain crops. But rarely will any of them affect all the crops. General farming is a practical demonstration of how wise it is not to put all the eggs in one basket.

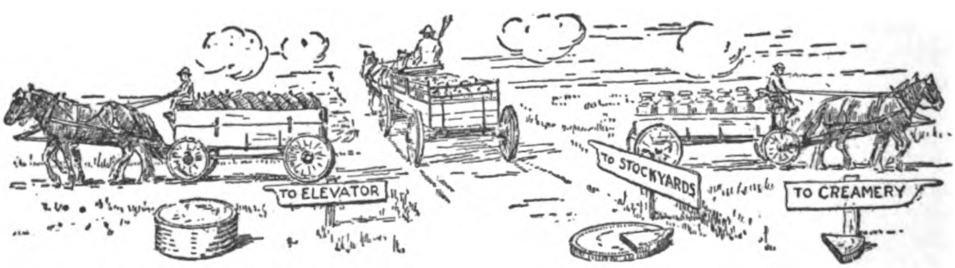


FIG. 168. One way to judge the relative merits of three types of farming. A load of grain, worth perhaps $50, takes $5 to $6 worth of fertility from the soil; a load of livestock, worth from $80 to $120, means a loss of about $1.20 in plant food; a load of cream, worth $150 to $180, takes but 20 cents worth of soil fertility. But, of course, all farmers cannot and do not want to produce cream. (University of Wisconsin.)

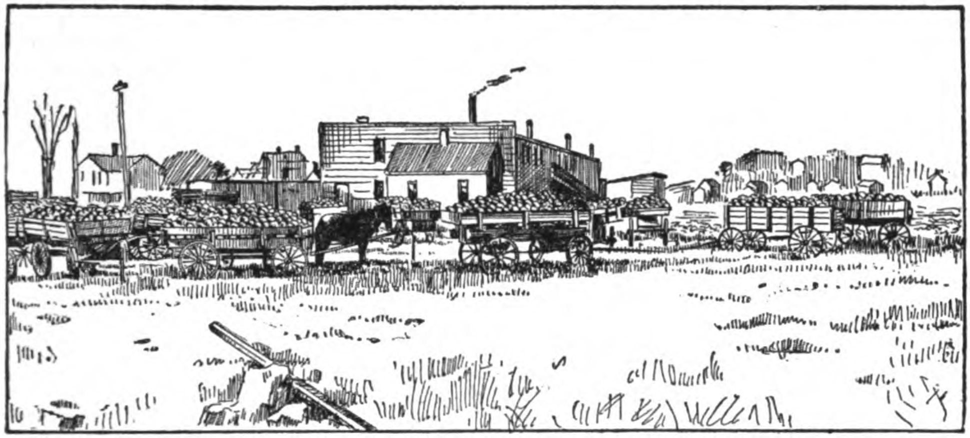


FIG. 169. Hauling cabbage to a sauerkraut factory. A characteristic feature of truck farming is its wholesale methods of marketing

CHAPTER 21

The Principles of Truck Farming

By PROFESSOR M. G. KAINS *(See Chapter 24), whose horticultural work has brought him into close contact with vegetable growing as well as fruit growing. Vegetable raising may be followed along 3 different lines. Truck farming, discussed here, is the most extensive phase, requiring the largest acreage, involving the largest crops and most closely resembling general farming in its methods. It is mainly a Southern activity. The other two lines—Market Gardening and Home Vegetable Gardening—are treated in Chapters 22 and 23.*—EDITOR.

TRUCK farming is the production of large quantities of staple vegetables for more or less distant markets. It is the most extensive form of vegetable growing, for commonly each crop is sent to market by the car- or ship-load, though sometimes by auto trucks or wagons. Its object is to fill the general channels of trade in big cities with a small number of the most necessary and the most easily shipped kinds of vegetables in large quantities. In scope it is, therefore, more restricted than market gardening (p. 178) while it lacks the intensive methods of kitchen gardening (p. 182).

The chief truck crops are cabbage, kale, lettuce, spinach, sweet potatoes, egg plants, potatoes, cucumbers, beets, radishes, and cauliflower. Onions and celery are cultivated as truck crops in some sections, but usually they are grown by specialists who raise few if any other crops for market. The only fruit that takes a prominent place on truck farms is the strawberry.

Important trucking areas. Truck farming has developed to meet the demands of great cities like New York, Boston, Philadelphia, and Chicago; for as the population changes from a producing to consuming one, certain favored localities develop into producing areas. In the New England States there are about 80 per cent consumers and some 20 per cent producers; in the southern states, the opposite is found. Thus in the latter area, the trucking business is enormous. Both climate and soil conditions are favorable, and cheap labor is generally available. Hence the ability to produce crops cheaply and in advance of areas farther north makes the business doubly profitable. The most notable trucking area extends

from southern Florida along the Atlantic Coast as far north as southern Maryland and to Delaware, covering a belt extending from 25 to 75 miles inland. Starting in the Far South, the harvesting season of each crop advances northward about 100 miles each week. The result is that northern cities are supplied with new potatoes for instance, from about the middle of April until the northern farms furnish the winter supplies in October. A similar though less clearly defined trucking area extends from the Mississippi delta northward on both sides of the river to Ohio and Illinois and, to a less extent, up the Missouri Valley. Texas, especially near the coast and along the Rio Grande, has of late years become an important source of truck crops.

Transportation. In order to handle the enormous business and move the perishable products quickly, railways and private refrigerator car lines have developed special equipment and fast freight train service. Steamship companies have followed suit. Because of these improved facilities, the business has developed rapidly and upon a safe foundation. Formerly, the steamers did the major part of the transporting, but in recent years, the railways have come to handle the great bulk of the crops because they can quickly reach a much larger number of cities. Distance to market is not measured in miles but in hours necessary for delivery.

Special features. Besides developing the aids to the business just mentioned, much has been done to produce special varieties and strains of vegetables suited for trucking. Usually these are of lower quality than those used by the home gardeners and, perhaps, even by market gardeners. As a class, they are "croppers" rather than long-season varieties, and may be gathered practically all at once. This helps reduce the cost of harvesting, favors large shipments and permits the quick use of the land for a succession crop. Most of these varieties are quick-maturing, good shippers, and specially adapted to the South.

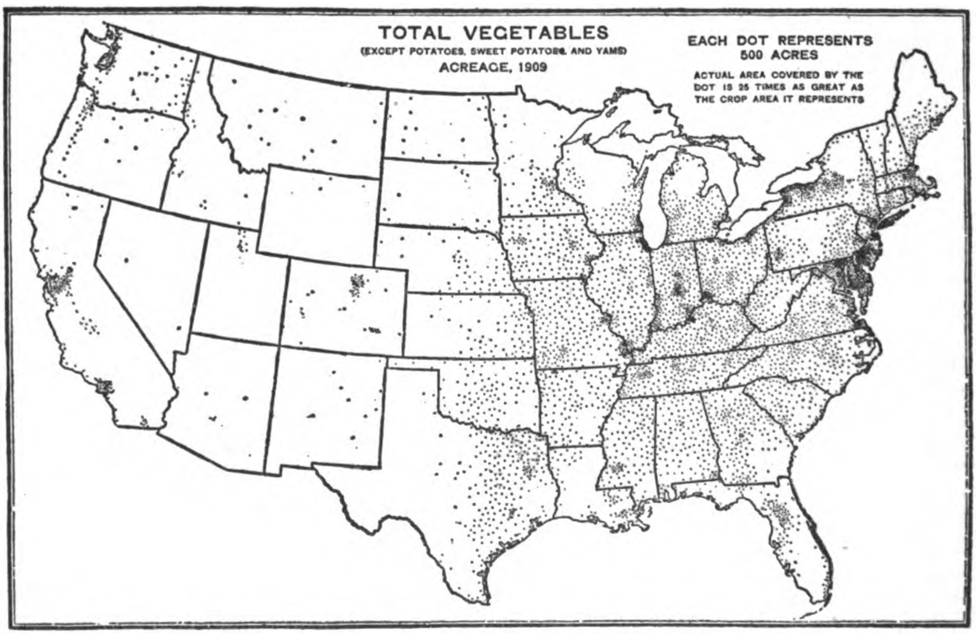


FIG. 170. Vegetable growing, especially as an intensive industry, naturally centres around large cities—the main consuming points. Light soils and early seasons also are favorable conditions. (1915 Yearbook, U. S. Dept. of Agr.)

Business ability required. The truck farmer must be both a good grower and a first-class business man, thoroughly equipped to overcome obstacles both in growing and marketing. He must be a good planner and also able to carry out his plans, so as to make the greatest use of his land by having a succession of crops from beginning to end of the growing season. More than this, his plan must fit into the general scheme of things both to the south and to the north of him, especially the latter. For he must aim to avoid coming into competition with similar crops that can be grown or shipped more cheaply than his. Southern truckers run less risk in growing early than late crops, because their products would reach market and be used before those from more northerly sections would arrive; Northern truckers may find late varieties of some kinds profitable because these often reach markets almost if not quite bare.

Labor supply. It is necessary to adjust the acreage to the available supply of labor. To secure best results, a staff of well-trained hands should be maintained throughout the year. Where the plan is properly made, such a gang will do better work and be more reliable than temporary, wandering labor. Given experienced men, sufficient numbers to the acreage, and an acreage properly proportioned to the kinds of crops, the labor, capital, and area can all be worked most economically; also the demands of the market can be met to best advantage.

FIG. 171. Harvesting and packing lettuce directly from the frames in which it was grown

Cultural Details

Rotation of Crops. It is usually easier to rotate crops in truck farming than in market gardening, because a larger area of land is generally available and its price being lower, the interest charge is less. The wider the rotation, the better. Four-year rotations are about as popular as in general farming. Usually the land is not left in sod for long, but instead of red clover, a shorter season legume is used, more as a green manure than as a hay crop, though hay is often harvested. The most popular legumes in truck gardening are cowpeas, bur clover, velvet beans, hairy vetch, crimson clover, and soy beans. Those tender to frost are usually sown in spring and perhaps a second time by midsummer, then followed by one of the hardy ones which even when used alone are rarely sown until early autumn. Before being plowed, the land is usually dressed liberally with manure or commercial fertilizer, or both. A gross feeding crop such as cabbage, potatoes, or corn generally follows the legume. Then come general truck crops for 2 years before another year of rest sown to legumes. Some growers believe they get as good results solely by the use of hardy legumes sown in the fall; but without care in planning the succession of crops to avoid repetition of the same sort, the results are likely to be disappointing. For the soil becomes "sick," and insects and plant diseases become increasingly troublesome. Especially is this the case where cabbage and its allies are grown continuously on the same area, but with cucumbers, melons, etc., the case is almost as bad. When once the land becomes full of disease, the only way to purify it is to rotate unrelated crops upon it for 4 or 5 years.

Succession of crops. Succession of crops is possible to a less degree in truck farming than in market gardening. Most truck gardeners use little or no glass but start their seeds in the open. Many who raise cabbage and certain other transplanted crops do not even grow their own plants but buy from specialists. Generally but one sowing or planting of a crop is made, because, earliness being the aim, the grower does not want a second crop which would compete with crops produced farther north. The truck grower plans to have a

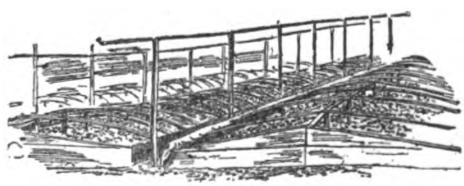


FIG. 172. Cheap, but adequate cold frames as used in the Carolina trucking sections. They are equipped with overhead irrigation and cloth covers which can be rolled back as shown, when not needed.

variety of crops that naturally follow one another through the season. A favorite way of doing this is to have 2 different crops upon the same area at the same time. One popular pair is potatoes and strawberries. After the potatoes are harvested early in the season, the berries have full possession. Perhaps a better combination is tomatoes or beans with strawberries, since neither of these vegetables requires the stirring of the soil to the possible disadvantage of the berries. In any case the companion crop should both pay the cost of growing the strawberries and also return a fair profit itself. Crops, such as parsnips, that demand a long season to mature are often companion cropped with cucumbers, cantaloupes, or tomatoes, since these hot weather lovers leave the roots in sole possession at the time they need plant food and moisture most. Cucumbers are often planted among string beans that are already "up." Quick growing crops—lettuce, spinach, radishes—are often planted between rows of other crops—cabbage, tomatoes, potatoes, etc. By combining these methods, a series of 3 or 4 crops may be secured in one season from the same area. In the South, a favorite cycle (1) is fall-sown lettuce sold in December; (2) lettuce again, sold in late March; (3) beans sown among the lettuce shortly before harvest and sold in late May; then (4) cowpeas for green manure plowed in October. This gives 3 highly profitable crops and one soil-enriching crop in a year.

Special equipment. In truck farming, advantage is taken of many devices to secure good work, insure good yield, and reduce the cost of management. Irrigation is practised to a less extent perhaps than in market gardening, but it is gaining in popularity, especially in the growing of delicate crops that demand ample water. Muslin-covered frames are extensively employed in the South, for winter culture of half-hardy plants—beets, carrots, lettuce. Disease and insect-fighting devices are also specially adapted to individual crops—beans, potatoes, etc.

Soils and soil fertility. In truck farming, soil and exposure are less important than easy transportation, yet they influence earliness. Heavy soils, being usually retentive of moisture, are ordinarily cold and therefore later than sandy and other light soils which may be plowed earlier in the season and cultivated sooner after rains. For such crops as celery and onions, cold, retentive soils are essential. The natural fertility of the soil is a secondary consideration since manuring, green manuring and fertilizing will adjust that. Abundant stable manure—20 to 50 tons to the acre—and quickly available fertilizers, at the rate of 500 to 2,000 pounds to the acre are most used by successful truckers. Because of the demands made by 3 or 4 crops in a season, no soil is naturally capable of supplying the needed plant food without liberal feeding.

Cultivation. Clean cultivation from the very start is the order in truck farming. To save time and labor, many cultivators use tools that handle 2 to 4 rows at a time. Hand work is reduced to the minimum because of its cost in time and money. Weeds are of small consequence on well-managed truck farms; constant cultivation prevents their becoming troublesome.

Harvesting, storing, and marketing. As truck crops are shipped to market in car-lots, harvesting is done wholesale, often with special machines. The whole area is usually cleared and in a few days fitted for a succeeding crop. Except in the case of sweet potatoes, cabbage and a few other crops—truck crops are rarely stored where grown but are almost invariably sent to and held in the cities. Marketing is usually done through commission houses direct to the general channels of trade—jobbers, wholesalers and retailers—though some is sold by auction and to large consumers such as canneries.

Handling the surplus. In truck growing, little if any use is made of the low-grade and excess products. These are usually left on the fields or hauled to other fields and plowed under. It is doubtful if a trucker could manage a cannery profitably as a side-line to handle only his surplus. He would need more constant and sure supplies, and the manufacturing would probably divert and demand too much of his attention. Whether it would pay him to keep livestock except, perhaps, hogs to eat such wastes is also doubtful. In fact, truck growing does not lend itself well to combination with any other line of farm work, unless it be hay and grain raising. Even these branches should be incidentals in the general rotation rather than leading crops. As in market gardening, the truck farmer may grow truck crops among young orchards which later are to be the main source of profit.

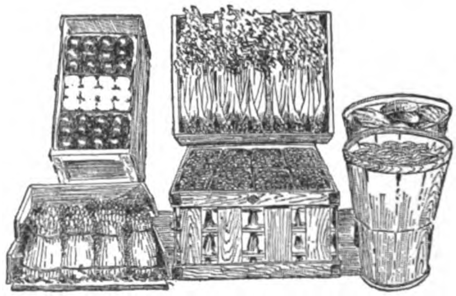


FIG. 173. Typical packages and containers for shipping truck crops. An attractive pack goes a great way toward bringing a good price.

GROWING CROPS FOR CANNERIES

THE growing of crops for canneries is being rapidly developed in certain sections of the United States where conditions as regards soil, climate, and transportation facilities are favorable. Excellent opportunities in this direction are offered, for instance, in regions particularly adapted for trucking but which are too far from a large city to warrant an attempt to grow perishable crops for sale fresh; or in regions where transportation facilities would not warrant car-lot shipments and where land values are, relatively speaking, low.

Some one crop for which the local cannery is especially equipped is usually put in as the leader, with several secondary crops grown to extend the season of operation. Thus we find sweet corn as a leading line in Maine, tomatoes in Delaware and New Jersey, and peas in Ohio, Michigan, and western New York. In the fruit belt of western New York, we find raspberries (especially such varieties as Columbian), and cherries, as leading lines, with other fruits raised and canned in lesser amounts and at other seasons.

In a large pea-growing region the canning season may begin with spinach about the first of June; a succession of seedings will keep the plant busy for 2 or 3 weeks, or until time for the first sowing of peas to mature. These will be out of the way by July 4 to 10, and a let-up of a day or two may occur before the later sowings of peas are ready; these will keep the factory operating another two or three weeks. Early-sown beets may be used to fill in the interval between peas and corn. Corn canning begins with the ripening of the first planting and lasts practically until frost. In some cases, string beans will be put up between times, while table beets, squash, pumpkins, and apples may be the last things of the season. In this way a plant will have an operating season of 5 months and can afford to import the labor needed for handling the crops and hold it for the season.

The soils favorable for such a business are those which lend themselves to easy cultivation and to high yields. They should be rich in organic matter and such as enable truck crops to make rapid, luscious growth. Sometimes a canning plant will contract for all its crops to be grown by the farmers in the community; in other cases it will operate a number of farms and add their production to that of its farmer patrons.

The advantages of a cannery to a locality are that it offers a ready market at a fair price for a number of perishable crops. It enables the farmers to grow cash crops, possibly in small areas, but which nevertheless add materially to the farm income. By careful arrangement of the acreage of different crops suited to a region, that region's income can be very greatly increased. In a fruit-growing district they are of great service in conserving that which might be wasted, and they frequently offer a very profitable outlet for large quantities of fruit, thus enabling the growers to avoid glutting markets.

The production of canning crops, since it more nearly approaches gardening, raises the tone of the agriculture of a region. Of the total cost of growing a crop of peas, that for the seed alone is often greater than the income from an average field of wheat. The contract system tends to stabilize prices, for under it the farmer knows just what he is to receive for his crop.

Cannery crops encourage the development of new methods. For instance, in the case of peas, usually 4 bushels are sown per acre with a grain drill. The rows are usually 7 inches apart. As soon as the crop is ready it is harvested by mowing with an ordinary mowing machine to which a pea swather is attached. This causes the pea vines to roll together in snakelike fashion so that they are quite easily forked on to the load. The peas are thrashed by thrashing machines and the farmer is paid by the number of pounds of peas delivered. In some cases the size of the peas influences the price; thus it might be 2 cents per pound for the largest, 4 for the second, and 6 for the smallest peas, so that if the farmer cuts his peas before they are ripe he gets an increased price. In other cases a flat price of 2¼ or 2½ cents per pound is paid and the pea seed is furnished at a nominal price of $2 per bushel. In this case the grower agrees to cut the peas on the day to be chosen by the canning company and to deliver all of the crop whether it be small or large.

By-products, such as pea vines and corn cobs, are returned or sold back to the farmer for stock feed. Usually they are made into big stacks from which the farmers haul loads during the winter as they need them, each grower being allowed 1¼ ton of the "silage" for each acre of peas grown. Such an industry therefore encourages the raising of livestock and the practice of mixed farming; indeed the growing of sweet corn almost necessitates the keeping of livestock to eat up the stalks. Of course this is not true where vast acreages of asparagus are grown for canning as in California, or where fruit is the main canned product. Again, growing crops for canneries involves coöperation. Furthermore, it introduces cash crops and tends to improve the agriculture of a locality generally. (By SAMUEL FRASER. See Chapter 25.)

CHAPTER 22

The Principles of Market Gardening

By PROFESSOR M. G. KAINS. *Market Gardening—the second system under which vegetables are grown—may be either an entire, specialized industry, or a small side line. In the first case it is a business for the suburban farmer, in the second it may fit in anywhere as a profitable opportunity for supplying one's neighbors with things they want but will not bother to raise. In either case, its relation to the feeding of the country's population makes it of tremendous importance.*—EDITOR.

MARKET **gardening** is the production of large quantities of many kinds of vegetables to supply local markets. It often includes the growing of strawberries, and less frequently, that of the bush fruits. Next to home or kitchen gardening (p. 182) it involves the most intensive plans and methods of management in crop growing. Its object is to supply a few customers or a small neighborhood with a considerable variety of vegetables and perhaps small fruits during the whole year, rather than an enormous amount of a few crops for short periods as in truck farming (p. 173). As a rural village grows into a manufacturing town and part of its population ceases to produce crops, market gardeners become necessary; and when towns become great cities, they create a demand for such large quantities of food that truck growing becomes necessary.

Market gardeners rarely cultivate more than 50 acres; probably the majority use less than 10. By using the most intensive methods, many make a good living off less than 5, though in such cases hotbeds, coldframes, and perhaps even greenhouses are required to a greater extent than on places of 10 acres or more.

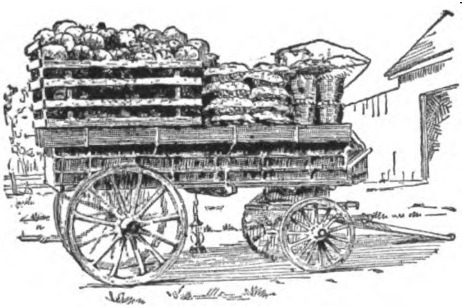


FIG. 174. A market garden wagon typical of sections where a long haul to market is called for

Relation to other farm work. When soil conditions will permit, market gardening may be combined with other farm work as part of the regular rotation of crops. As there is always more or less low-grade produce—trimmings, waste leaves and the like—it is often advisable to keep livestock, especially pigs, to turn this otherwise waste material into profit.

Location. Always the market gardener must be situated within easy hauling distance of his market. Formerly this was limited to an easy wagon haul; nowadays auto trucks have extended it to 20, 30, and even 50 miles. In some cases, the plan of sale is to visit the homes of customers; in others it means conducting market stalls or selling direct from the wagon or truck at the "farmers' market." The two plans are often combined. Many growers also sell at wholesale to green grocers who retail the products. Often the telephone is used for taking private customers' orders, and often postal cards giving lists of crops expected to be ready the next marketing day are mailed a week or so in advance of it.

Market gardening is costly. Because it is carried on near towns and cities, market gardening demands a good deal of capital and skill. The land is often valued at $1,000 an acre or more, so a high interest or rental charge must be met;

this means that the utmost must be made from all the land by adopting various intensive cropping systems. In order to insure against loss by drought, overhead irrigation is being more and more generally installed in market gardens—and this is another costly feature. Also, since the crops must be planted close together, hand tools are necessary, which means that high-priced, human labor instead of animal power must be used. Little tractors are coming on the market, but as yet are in the experimental stage. Doubtless they will eventually reduce the amount of hand labor required, but so far they are costly. Of course, manures and fertilizers must be used lavishly or both quantity and quality of product will be inferior. All in all, market gardening is a costly business, but when properly handled and when the crops are skilfully sold, it is very profitable.

FIG. 175. A valuable aid to the market gardener

Where to locate. While many people start in a very small way, perhaps in the home garden, and gradually develop a good market gardening business, too much attention can hardly be paid to local demand and supply when a new location is to be chosen. For no matter how skilful the gardener, if the market is already well supplied with the crops he has to offer or does not like his products, he will have a hard time of it. Apart from this, the roads must be good even in the worst of weather, else he cannot reach market. Better a long haul over a good road than a short journey over a bad one, especially if it must be repeated day after day. It is easier on teams and men, and the produce will be delivered in better shape. An abundant supply of stable manure at reasonable prices, must be readily available. In many cases, the large city is the surest source. Unless the would-be market gardener has a family of working ages, it is also important to consider the available labor supply of the neighborhood, especially during the harvesting season

FIG. 176. A well-made compost heap being cut and re-piled to complete its rotting

Market Gardening Methods

Soils. Because of ease of handling, earliness, and cleanliness, a sandy loam soil is preferred to anything heavier. While plant food is more likely to be lost from such a soil, this fault is more than offset by its advantages. On such a soil good management will produce highest quality crops earliest in the season when prices are highest. It is vital that the soil either be naturally very fertile or be made and kept so. Unless kept in excellent physical condition also, the yields are sure to be unsatisfactory.

Fertilizing. Plant food in available form must be abundant during the growing season, and legumes must always be present to maintain the desired physical condition. To insure these conditions most market gardeners apply 40 to 60 tons of stable manure to the acre every year. In addition, many use commercial fertilizers in amounts varying from a few

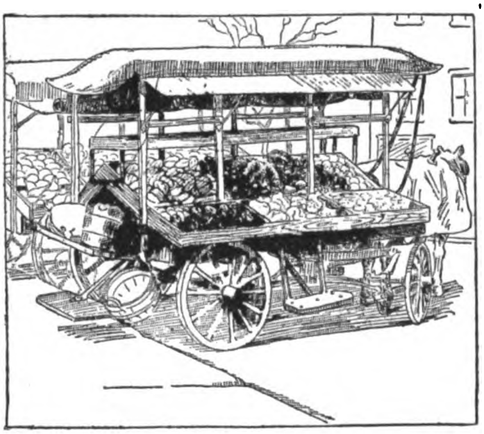


FIG. 177. The market gardener may often find a retail business a profitable activity

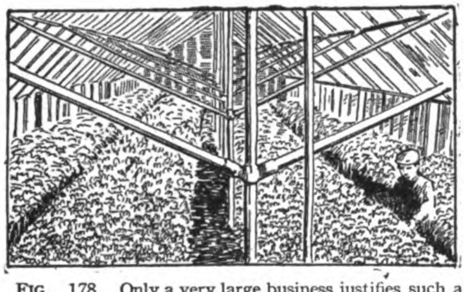


FIG. 178. Only a very large business justifies such a greenhouse as this, but some means of starting plants early, under heat is essential.

hundred pounds to as much as 2 tons per acre. While complete fertilizers are usually preferred, those rich in nitrogen—especially nitrate of soda—are often applied separately as small top-dressings several times during the growing season. Popular general mixtures contain 4 per cent nitrogen, and 7 to 10 per cent each of potash and phosphoric acid. When the soil is heavy or sour, lime is used to lighten and sweeten it. It also tends to destroy certain disease germs such as those of cabbage clubroot.

Making the largest yields from the smallest areas. In order to make the most out of a given area, every available square inch must be kept busy all season long. Many methods are adopted for doing this. Where no greenhouse is available hotbeds and coldframes are used, the former to start, the latter to "carry along" the plants, sometimes to edible maturity but usually only until the season has settled enough to permit of their being planted out in the open. To follow this earliest hotbed crop, later sowings are made in specially prepared, outdoor seedbeds as soon as the weather permits, and these seedlings are transplanted to the open after those started under glass have been planted out. The glass is also used to extend the season in the fall when, unless protected, tender plants would be destroyed. In mild climates cloth sash is often used instead of glass. The first sowings of hardy crops are made as soon as the ground can be worked. These are succeeded by later sowings or plantings from the cold frames according to one of the following plans:

Marker cropping. This method is employed to some extent with slow-germinating seeds like parsnip and with plants such as onion of which seedlings are hard to see at first. It means simply that a quick-starting, quick-maturing, easily-seen crop is sown in the same rows with the slow crop. Turnip-rooted radish is the favorite for this because its seedlings appear in less than a week, and are harvested in 3 to 5 weeks. Any marker crop should always be sown very thinly so as not to crowd the more important long-season crop which follows it.

Companion cropping. This method consists in putting 2 or 3 kinds of crops in the same place at the same time, the individual large and small or quick and slow growing plants being alternated either in the same row or in neighboring rows. A favorite market garden combination is lettuce plants placed alternately in rows with early cabbage and horseradish planted deeply between the cabbage rows. The lettuce is gathered before the cabbage needs the space; then when the latter is removed the horseradish nas the ground for the rest of the season. Thus three crops are taken off in one year.

Succession cropping. In this method each crop is cleared out as soon as marketable to make room for the next. The plan is worked in two ways: (1) A quick-maturing crop such as lettuce, onion sets, or radishes is sown or planted as early as possible in spring so it may be harvested in time for a tender crop such as beans, tomatoes, or cantaloupes which can not be planted out of doors until danger from frost has passed. In some cases, the second crop may in turn be succeeded by a hardy, late fall crop such as spinach or kale, but often it is considered better practice to sow a winter cover crop among the tender crop toward the close of summer. (2) The second succession scheme is to sow the same kind of crop to succeed itself. Of the two plans, the former is the better and the more popular.

A combination plan. These three plans are often combined. For instance, radishes may be sown as a market crop with parsnips in rows alternating with cabbage and lettuce planted as companion crops. After the lettuee and cabbage are harvested sweet corn is sown where the lettuce plants stood. As a further succession, turnips may be sown broadcast among the sweet corn shortly after midsummer. Of course, such combinations demand high feeding of the land.

Rotations of crops. Just as in other farming operations, it is advisable to practise as perfect a rotation of crops as possible. Any crop or group of related crops (especially the cabbage and melon families) when grown continuously on the same area, tends to lose in quality and productivity, both because of the removal of certain plant foods and because

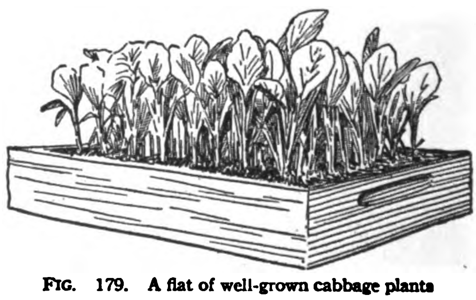


FIG. 179. A flat of well-grown cabbage plants

diseases and insect enemies, especially injurious to that crop or group tend to increase. Where continuous cropping with related crops is carried on, it often becomes necessary to finally abandon their culture for several years until the land "comes back," and the diseases and insects are starved out. By following one crop with something very unlike it in demands upon the soil, fertility is maintained and, to a greater or less extent, insect and plant pests are avoided.

Cover crops. Wherever possible, it is advisable to include red or mammoth clover in the rotation because of both the vegetable matter and the nitrogen they add to the soil when plowed under. As these crops require at least one whole season to mature, they are less popular than some other quicker growing legumes. Cowpeas and soy beans are admirable for midspring sowing and summer growth; crimson clover and winter vetch are fine for late summer sowing either among other crops or upon early fall-plowed and harrowed land. As crops to follow such legumes, corn and potatoes are very popular.

Irrigation. In arid parts of the country, irrigation is, of course, essential to success in market gardening. The furrow system is probably the most popular. In other sections of some rainfall but frequently where droughts occur during the growing season, overhead irrigation, though costly, is not only a form of crop insurance, but also a means of hastening the crops. For when one crop is removed, the ground may be drenched, plowed, and replanted or resown and the succeeding crop given ideal conditions from the very start. Thus the growing period of each crop may be shortened somewhat, and a higher quality product secured.

Harvesting and storing. Methods of harvesting, storing, and marketing differ widely with the kind of crop. Salad crops—lettuce, endive, cress, etc.—must be handled quickly so they will not wilt before they reach the consumer's table. They can not be held for more than a few hours without damage. Some other crops—peas, corn, and beans—are almost as particular, because they lose flavor if delayed on the route between garden and kitchen. The fruit crops—cucumbers, cantaloupes, tomatoes, etc.—may be held for several days under favorable temperature conditions. Indeed, when necessary, they may be picked before thoroughly ripe; but it is better to let them reach full perfection before gathering them. The root crops—beets, carrots, parsnips, etc.—may be handled slowly with less chance of being injured than any of the others, but those gathered for bunching should not be allowed to shrivel. All these, as well as cabbage, potatoes, and sweet potatoes may be readily stored for winter use. Some kinds—Jerusalem artichokes, parsnips, and salsify—may even be allowed to remain in the garden over winter (see Chapter 28.)

Marketing. Each vegetable is sold in its own way. Immense quantities of market garden crops are sold in "bunches." The plants are harvested, washed, trimmed, and tied in bundles of 1, 2, 5, and 10 cents' worth as they will be delivered to customers. In many cases as of peas, beans, onions, tomatoes, etc., sales are made upon a basis of weight or measure. Sometimes a number is the unit as with melons, cucumbers, corn, globe artichokes, etc. Market gardeners usually sell in small quantities for immediate consumption, but in late fall easily stored vegetables, especially root crops, cabbage, squash, potatoes, and pumpkins, are handled in larger quantities as winter supplies. It is often more profitable to take the lower prices that rule at that time than to run the risk of loss due to storing; for the advanced price in winter and early spring may not offset the shrinkage.

Handling the surplus. Unless salad crops can be fed to animals, their surplus must be a loss. This is true of all crops that cannot be canned, dried or otherwise worked over into a salable product. Hence it is wise to plant such crops sparingly and to devote the time, space and energy to those that can be manufactured if not sold fresh—corn, tomatoes, peppers, onions, beans, peas, etc. There is such a good demand for canned and dried fruits and vegetables, sauces, etc., that it may pay a market gardener to develop a department for handling the surplus and low grade products he cannot always avoid having on hand.

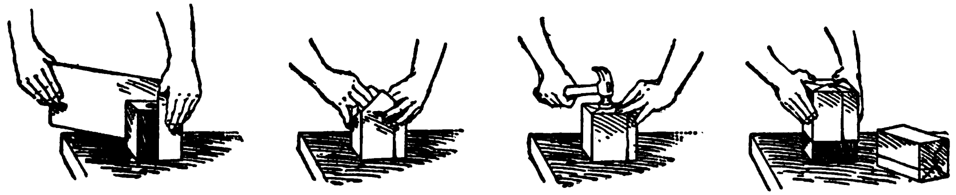


FIG. 180. Four steps in an easy method of making paper pots for starting plants indoors. Wrap a strip of paper around a wooden block bolted to the table; fold in the opposite sides; then drive a small tack through the centre, riveting it on the head of the bolt.

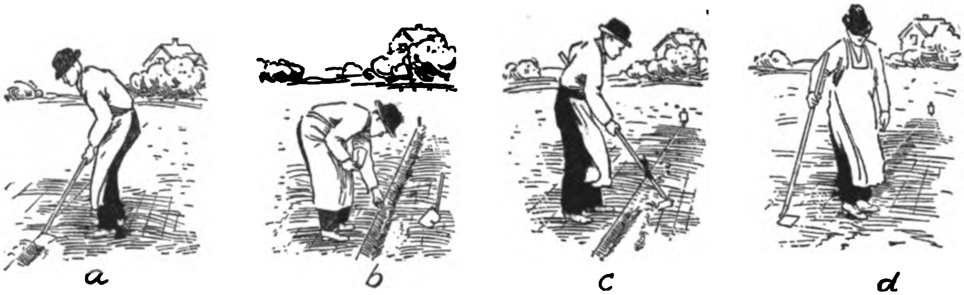


FIG. 181. Four steps in planting large seeds. Make a furrow with the corner of a hoe, using a line to keep it straight; drop the seed evenly and at a uniform depth; cover evenly and to the depth called for by the seed, the soil type and the season; firm well by treading down the row.

CHAPTER 23

Principles of Home or Kitchen Gardening

By PROFESSOR M. G. KAINS (*See Chapter 24*) *who, while teaching others how to do it, has also for many years raised enough vegetables in his own garden to supply his family's needs the year 'round. On many farms the garden is not given a chance to show what it can do. The commonest causes of failure are* (1) *insufficient preparation of the soil*; (2) *lack of a planting plan*; (3) *an attempt to do all the planting for the entire season at one time*; (4) *carelessness or ignorance in choosing sorts of vegetables and varieties*; *and* (5) *insufficient care during the growing and ripening seasons. The following directions, together with Chapter 28, should enable any farmer to avoid these pitfalls and make a successful, profitable garden.*—EDITOR.

THE home or kitchen garden is the most important and often the most profitable area on the farm, or the village, city, or suburban lot, because when properly managed, it may be made to supply an astonishingly large variety and quantity of produce at far less than the same quality and quantity of purchased food would cost. While such gardens usually contain fruits, and often flowers, only the vegetable side is considered here.

The value of vegetables. Vegetables are of value as food because they supply certain things needed by the body but not obtainable from meat or grains. Also they add palatable flavors and appetizers, and in many ways, favor good living at low cost. Finally the home garden insures freshness which, with many vegetables, especially salads, corn and peas, is essential to their best condition for the table. As to the money value of the home garden, experiences have often shown gross returns of 25 to 50 cents a square foot at a cost of 15 to 20 cents or less. The skilfully managed garden may easily mean an increased income for so-called "middle-class" workers, and an increased, improved food supply for any one. No farm should be without its garden.

Varieties for the home garden. The market gardener and trucker grow considerable areas of one kind of crop (usually of only middling quality or less) so as to have "enough to sell" in wagon- or car-load lots. The home gardener on the other hand can and should plant only the choicest varieties in just the right amounts to supply his table for the longest possible season. Varieties for home use should always be of the best quality, not of the market standard which is often coarser, less appetizing and usually larger. The seed should be bought from a thoroughly reliable seedsman. Many dealers do a mail-order and parcel-post business, others sell through local stores. In the latter case, disappointment

often results because the seeds are old. The only safe guide is the reputation of the firm that puts up the packets. It is well to test several varieties of a kind each year because, while some do better than others, there is no way to discover except by growing them, which one does best in any particular garden. While it is safest to depend on well-known standard sorts for the main supply, it is interesting and profitable to try out a few strangers or novelties each season. Vegetable varieties and strains are so numerous and change so rapidly that no attempt will be made to give complete lists. Types and groups are mentioned in Chapter 23 whenever possible, and varieties are sometimes named to illustrate them.

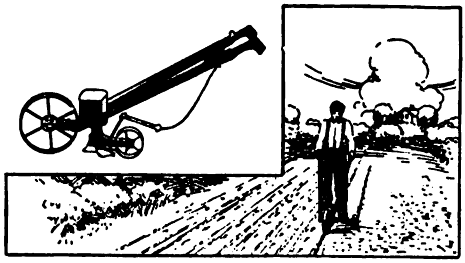


FIG. 182. The wheel-hoe equipped with a seed drill attachment saves much time and back breaking work.

Home-grown seeds. It is hardly worth while for the farmer to attempt to raise any considerable proportion of the garden seeds he uses. As a rule they can be bought cheaper and of as good, if not better, quality. Indeed, the home saving of seed as ordinarily done is very unsatisfactory. Usually the poorest specimens —those always passed over in harvesting—are allowed to ripen seed, with the result that the plants are poorer and poorer each year. The best results follow a system of selection of seed from the choicest plants for the tendency in all breeding is for the character of the parent to appear in the offspring. The first point in such work is to know clearly just what one is selecting for, and then to stick to that line. For instance, if the plant that bears the first ripe cucumber or tomato is chosen as the seed-bearing parent every year, this early-bearing characteristic will tend to appear more and more strongly. Always the whole plant and not the fruit should be the basis of choice; for often some unexpected cause may mature a single fruit far ahead of the rest on the plant, while another plant near by may be a few days later but will ripen all its fruits close together.

Equipment. Most of the tools needed in the garden are part of every farm's outfit. Those that must be had are spade, spading fork, rake, hoe, wheelbarrow and garden line or tape. Other useful implements, to be added as soon as possible, are a trowel, extra hoes of special forms, cultivators or weeders, a hose or watering pot. A great labor saver that will take the place of several of these is the combination wheel hoe, which, by means of different attachments, makes furrows, harrows, hoes and rakes as fast as the operator can walk. If the garden covers half an acre or more the seed-drill attachment is a further time and labor saver at planting time. A spray pump that can be carried on the back is a good investment unless the farm already possesses a larger type that can be used. There are on the market many hand tools and special devices invented to make garden work easier, and some of these are extremely helpful under the right conditions; but every person must try out each one for himself—provided he can justify the expense of adding them to his equipment on the chance of their making good. (See Chapter 11, Vol. III, for a more detailed discussion of tools, their construction and their uses.)

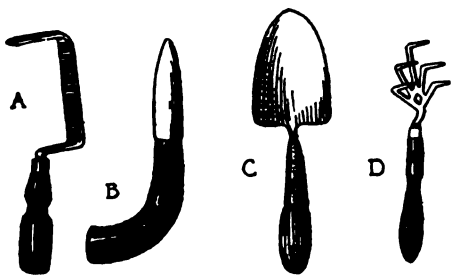


FIG. 183. Four useful hand tools; *a* flat blade weeder; *b* dibble for planting seedlings; *c* all-round trowel; and *d* claw weeder.

General Principles of Garden Making

Gardens in different parts of the country will naturally differ as to what can be grown in them and how they should be handled, but there are certain principles that hold good practically everywhere. These, in the main, deal with *location, soil treatment,* and *choice and arrangement of crops.*

Location. The garden should be close to the buildings, especially the house, so it will receive attention often and so vegetables may be quickly and easily obtained just when wanted. If possible a southeastern exposure should be chosen, since it warms up quickly early in the spring and early each day. A gentle slope is an advantage in that it assists the drainage of the plot. If a woodlot, hill, tight board fence, hedge or group of buildings protects it on the side from which come most of the winds of the growing season, so much the better. Of course this protection should not cast too dense a shade, nor should the trees or hedge be so close as to rob the soil of moisture or plant food. An ample water supply to help out in times of drought is a great aid in growing large, high-quality crops. A good fence of woven wire or poultry netting sets off the plot, gives it added importance, and often prevents considerable damage by poultry, dogs or larger animals. A few flowers add to the appearance of the garden, but the determination to make it an area of the greatest possible practicable usefulness should always be kept uppermost in the gardener's mind. Finally the care of the garden should be a recognized, regular task definitely assigned to one or more members of the family. A plot that every one is going to look after often ends up by being cared for by no one. And the best garden in the country will not prove economical if neglected. A little attention regularly, every few days will do more than a solid week of work once in 2 or 3 months.

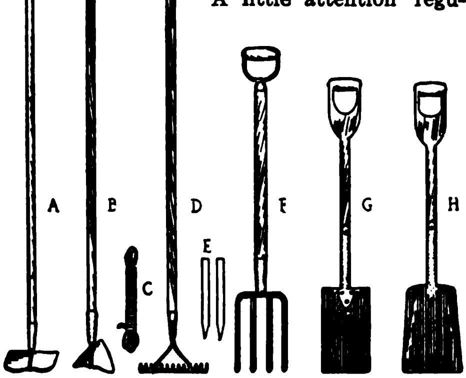


FIG. 184. Practically every one of these familiar tools is essential in a well cared for garden

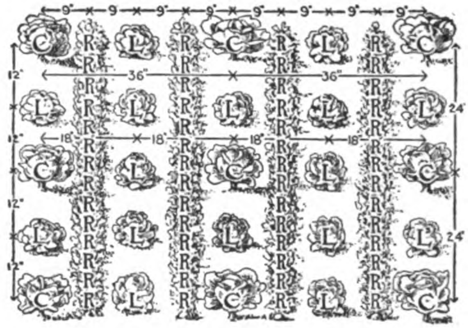


FIG. 185. An excellent example of companion planting. R stands for radish, L for lettuce, C for cabbage. The smallest matures and is removed first, giving room for the development of the next in size.

Soil. The character of the soil is of more importance in a garden than in a fruit plantation. The best soil is a fairly fine-grained, thoroughly well-drained sandy loam of moderate richness. Clay and other heavy soils become sticky when wet; dry slowly; are hard to work; and, unless handled just right, are likely to be lumpy when dry. While they do not readily take up water, yet they hold both water and plant food well. Because of their slowness in drying, they are cold and delay planting operations in the spring. Sandy soils are just the reverse; they quickly get rid of excess water; may be worked while wet; and are warm and early. One fault is that they allow plant food to escape too quickly, either by leaching or by "burning" of the vegetable matter. To keep them in good condition it is necessary to add abundant vegetable matter, either as stable manure, green manure or cover crops. To lighten and improve clay soils, sand, coal ashes, and vegetable matter of all kinds are excellent. A clay soil lightened by annual applications of these materials will in time become ideal, provided it is well drained and otherwise favorable as already mentioned. Usually dark-colored soils are better than light-colored ones because they are warmer and probably richer. Soils free from plant disease organisms and perennial weeds are naturally preferable to those infested by such pests. A year or two of preparation in getting rid of them is often time well spent. For the same reason it is well occasionally to change the location of the garden so as to let the old land rest and free itself from insects and diseases.

Fertilizing. To keep the garden in the best condition from year to year, liberal dressings of stable manure must be applied. This means a good wheel-barrow load every 6 or 8 feet and as much more as can be worked in whenever the soil is plowed or dug over. Fresh manure may be used in the fall and

HOW MUCH FERTILIZER TO USE ON SMALL AREAS

Lbs. per acre .	100	500	1,000	1,500	2,000
Lbs. per foot of row . .	⅛	¾	1½	2¼	3
Lbs. per plot 20 x 20 feet .	1	5	10	15	20

winter, but for spring only well-rotted manure is suitable and safe. Whenever ground is to stand idle, a cover crop should be sown and later turned under. Potash and phosphoric acid fertilizers benefit most soils and should be added when the land is fitted in the spring. Nitrate of soda is a valuable stimulant but is best used only during the growing season when it is less likely to be wasted. Wood ashes and lime sweeten and improve the physical condition of the soil and may be safely used in amounts up to 15 pounds per square rod. All sorts of vegetable refuse, garbage, bone scraps, etc., increase the supply of plant food, but they should be allowed to rot thoroughly before being used. The best plan is to keep a compost heap near the garden on which all vegetable waste can be thrown, sprinkled lightly with lime, covered occasionally with loam or sods and allowed to break down into rich humus; manure may be added to such a pile if desired. About a year is required to bring it into good condition.

Soil preparation. Deep plowing or spading, then careful, thorough harrowing or raking are essential in preparing the soil for either seed or young plants. Deep working improves the physical condition of the soil, increases its ability to retain moisture, makes plant food available and destroys weeds. Shallow top soils should be deepened gradually—about an inch a year—so as not to bring the stiff, cold, rather unproductive subsoil too quickly to the surface. Heavy soils must not be worked when wet or they will puddle, bake and become unmanageable, perhaps for several years. The proper time is when the lumps will crumble readily. Late fall plowing or digging benefits heavy clay soils by letting the winter weather break down the clods.

Planning the garden. To get the most from a given area, a plan must be made showing how every square inch of soil may be kept busy all season. Plans will naturally differ with different persons, purposes, parts of the country, crops to be grown, etc., but the following suggestions fit most conditions: First, make a list of the crops to be grown, keeping the perennials, the long-season and the short-season kinds separate. Place the perennials at one side of the garden out of the way. When possible, have the garden long and narrow rather than square, and run the rows the long way so as to save time in cultivating by cutting down the number of turns. There is often an advantage with tall-growing and climbing crops—corn, peas, beans, etc.—in running the rows north and south rather than east and west; but with low-growing kinds—carrots, beets, lettuce, etc.—the difference is slight as these crops do not seriously shade each other. For convenience and time-saving in cultivation with the wheel hoe, it is well to choose a unit distance between rows —12, 15, or 18 inches— rather than to mix such distances, because this avoids re-setting the tool. Another good plan is to have short-season crops such as lettuce, spinach, and radish in alternate rows, with the long-season ones such as parsnip, salsify and leeks so that when the former are gathered, the

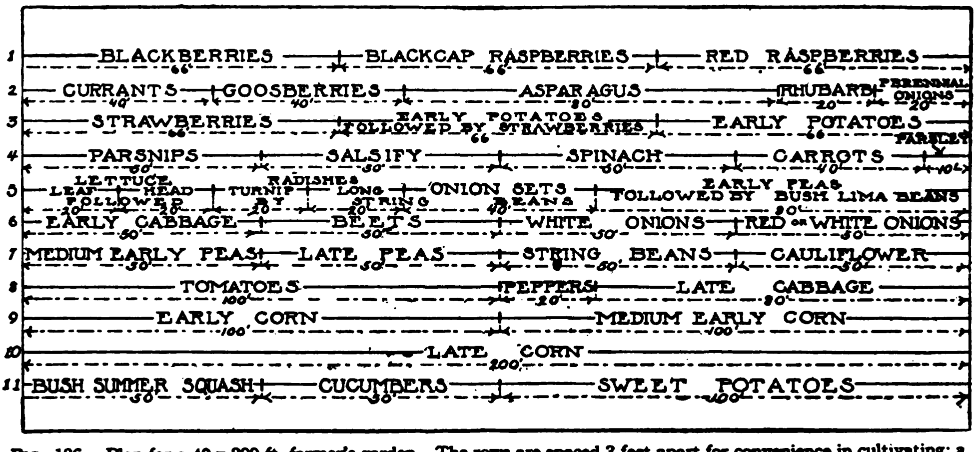


FIG. 186. Plan for a 40 x 200-ft. farmer's garden. The rows are spaced 3 feet apart for convenience in cultivating; a limited amount of succession cropping makes planting easier. (Compiled from Mich. Bulletin 4.)

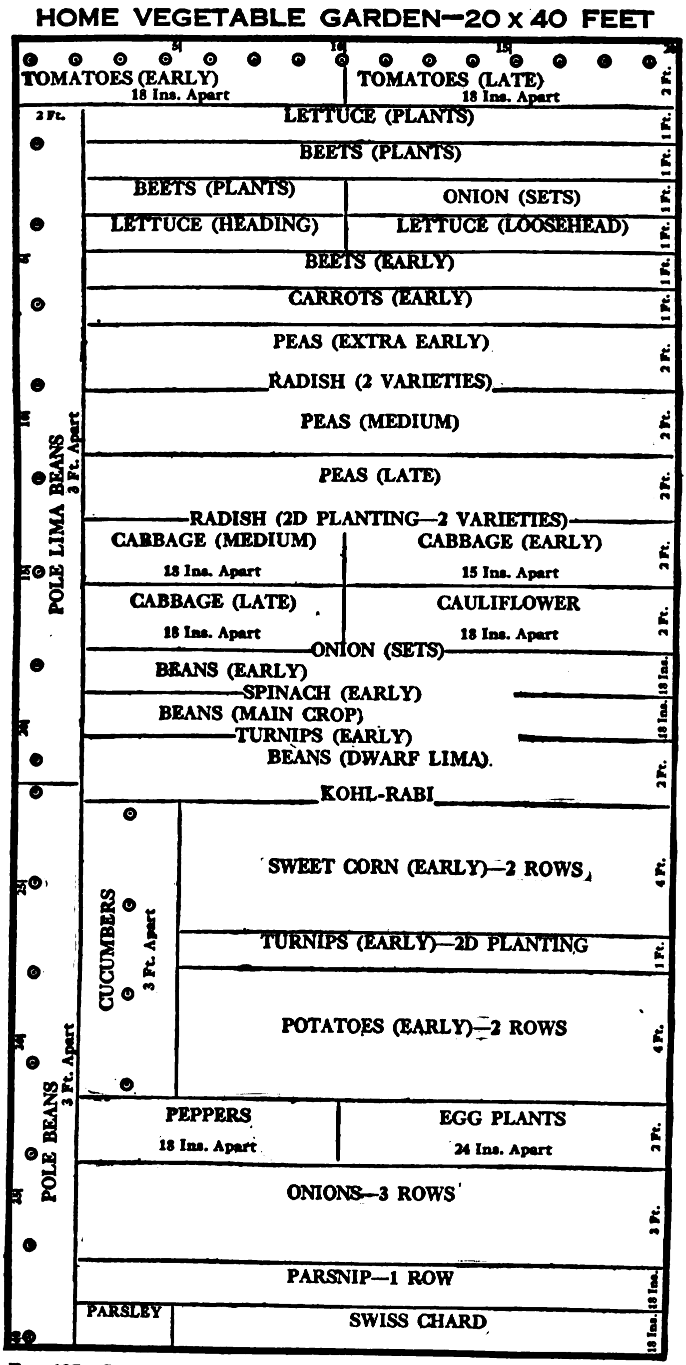


FIG. 187. Plan for a small, back-yard garden which makes good use of every foot of space. (Courtesy W. Atlee Burpee & Company)

latter will have all the space. This plan permits much shorter distances between rows at planting time. Some gardeners, however, prefer to keep all the short-season crops together, so that, when they are removed, all the space they have occupied may be planted to later crops.

Late-sown crops. While many vegetables sown in spring are not ready until fall, and while many others have passed by that time, certain kinds may be sown after midsummer to fill in the gaps. Under conditions similar to those on Long Island, for instance, beans may be sown every 2 weeks till September first; early varieties of carrots and beets till mid August; Chinese cabbage or petsai in July or August; sweet corn till August first; corn salad and garden cress for fall use through August and September; pickling cucumbers as late as July; kale in June; kohl-rabi in July; lettuce through August; early pea varieties in July and August; radish till mid or even late September; rutabagas in June; spinach in August and September; swiss chard till late August; turnip till mid August. A light covering of straw will protect corn salad, spinach and lettuce so these crops may be gathered at Christmas.

Gardening Operations

Seed sowing. The discussion of each crop (Chapter 28) gives general points and so also do most seed catalogues and packets. It is important to know one's own climatic and soil conditions, so as to judge when to sow. Until experience has been gained, thick sowing is perhaps

safer than thin; even though many plants must later be destroyed in thinning; whereas thin sowing largely saves this tedious work. Seeds may be sown shallower in spring when the soil is moist than when dry as in summer; and they should be sown shallower in clayey than in sandy soils. Seed soaking, though practised by many gardeners, is of doubtful value. If the soil is always firmed around the seed, plenty of moisture will usually reach it. This firming is especially necessary when the ground is dry. Sowing in drills is almost always better than broadcasting, because the plants can be given better care. Sowing of small quantities of seed is done in many ways, three popular methods are: (1) to work the seeds slowly with the thumb over the second joint of the forefinger; (2) to use the seed packet cut squarely across the end as a hopper which, as it is moved up the row, is shaken just enough to let the seed fall in the row as thinly as desired; (3) to use the hand as a hopper, the seed being dropped over

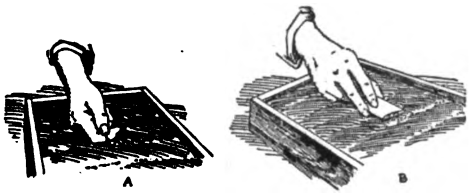


FIG. 188. Two ways to sow small seed (see text)

the end of the middle finger. Seed drills are good for larger quantities of seed, but they require considerable skill to prevent too thick planting.

Forcing and protecting plants. Methods employed in gaining time and extending the seasons for plant growth include the use of greenhouses, hotbeds, coldframes and various kinds of forcing boxes. Glass is a better protector than oiled paper or cloth because it admits more light and heat, but it makes heavier equipment and requires more care to prevent the plants from becoming spindly. The hotbed is the best substitute for a greenhouse and the coldframe next best, but before describing these we should give a few words to the other devices.

A forcing box is made 8 to 12 inches square, open at the bottom and closed at the top with a pane of glass sliding in a groove so air may be given as desired. It is useful for single hills of melons, cucumbers, beans, etc., but demands a good deal of attention in proportion to the amount of ground covered. *The folding hand glass* is made from two panes fitted into an inverted V-shaped galvanized iron frame to form a roof and if desired closed at the ends with waterproof muslin to allow for ventilation. It may be made continuous for any length of row and when not needed may be taken apart and stored in small space. *The cloche*, a bell-shaped hand glass like a cake cover, is often used for individual

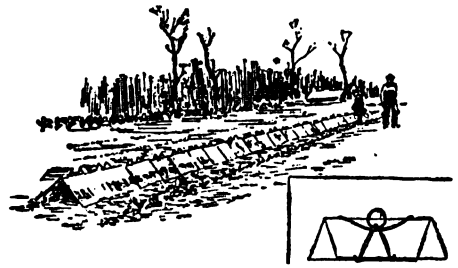


FIG. 189. One form of folding hand glass or plant forcer which can be used over a single hill or an entire row

plants. It is expensive, easily broken and less desirable than the other styles mentioned, though popular among European gardeners. *The forcing hill*, cheapest of all, is made by packing soil around a bucket or box mold narrower below than above, removing the mold, planting seeds in the hollow and covering it with a pane of glass. Though rain may break down the sides this is a simple and effective way to force plants in spring.

The coldframe is exceedingly useful in any temperate-climate garden. It helps along, protects and hardens off plants in spring, and is a good place in which to store them in autumn. It is placed on the ground surface in a sunny but sheltered situation, preferably against the south side of a building. For the simplest construction, 2 x 3 inch stakes are driven near the ends and at the middle of 12-foot boards placed on edge nearly 6 feet apart (5 feet 9 inches for the standard, 3 by 6-foot sash frames). These are connected by end boards and all are nailed or bolted together. The height at the back should be 18 inches and that at the front 12 inches; the slope will shed water and catch sunlight. The frames may be any desired length, but preferably in multiples of 3 feet ½ inch because each standard sash requires that much space. The soil to be used should be carefully prepared, mellow and rich to insure good growth.

In autumn place the sashes on the frames only when there is danger of freezing, and remove them each morning after the air warms up. For the first week or so the sash may have

FIG. 190. A handy 4-frame hotbed for the home garden showing *a* lath cover to provide shade; *b* straw mat for cold-weather protection; *c* frame uncovered, sash in background; *d* sash partly raised for ventilation.

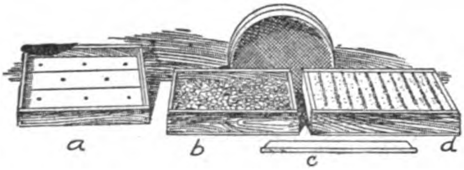


FIG. 191. A flat complete and in the making: *a* empty, showing drainage holes; *b* layer of drainage material; *c* beveled stick for making rows; *d* flat filled and furrows ready for seed; soil sieve in background.

to be kept raised an inch or two for ventilation and to keep the plants from getting tender. In very cold weather, say lower than 15 degrees above zero, mats, old quilts, shutters or other coverings are necessary at night and on cold, cloudy days. Take the extra coverings off in the daytime unless the soil in the frames was already frozen when they were applied; then leave them perhaps 3 or 4 days. Remove snow under the same circumstances.

The cold pit is the same as the coldframe except that it is dug out 2 to 5 feet below the ground level so that plants may stand erect in it. It is more used for ornamental plants than for vegetables. It gives better protection than the coldframe because of the larger volume of air and is therefore preferable for semi-hardy plants—unless a greenhouse is available—and for hardy ones to be retarded for successional blossoming. Often the pits are floored at the surface of the ground thus leaving a sort of cellar below for plant storage and a shelf of soil above for flowering or vegetable plants.

The hotbed, the next best thing to a greenhouse, is especially valuable for starting plants in early spring. Its construction is the same as that of a coldframe except that an excavation 1½ to 2 feet deep is made, usually boarded to the bottom and filled with fresh horse manure. The best way to handle the manure is as follows: Get what is needed fresh from the stable; add its bulk of leaves, tan bark or spent hops; mix well and pile in a well-tramped heap; in 2 or 3 days when it is steaming well, fork it over and make a new pile with the outer part of the first on the inside of the new one. In very cold weather this work had best be done in a shed or the piles be covered with straw to prevent too great chilling before fermentation starts.

After the second fermentation, place the manure in the hotbed and tramp it down layer by layer to the desired depth—perhaps 3 feet in cold climates, shallower in mild ones

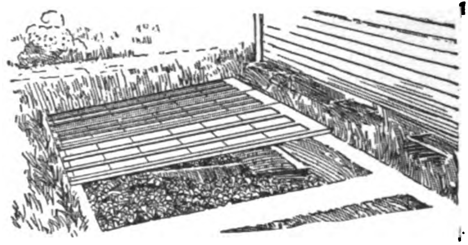
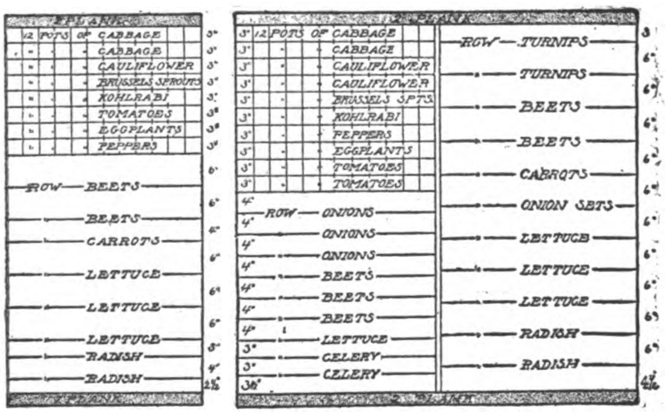


FIG. 192. A concrete hotbed foundation is permanent, strong, neat in appearance, and both easy and economical to make.

—then put on the sashes and let stand a day or so. If properly handled the heat in the manure will be 100 degrees or more by that time. In 2 or 3 days the temperature should have fallen to about 90 degrees, when 3 to 6 inches of rich, mellow, light soil must be spread on the manure and well firmed. Keep the sashes on for 3 or 4 days to warm the soil thoroughly.

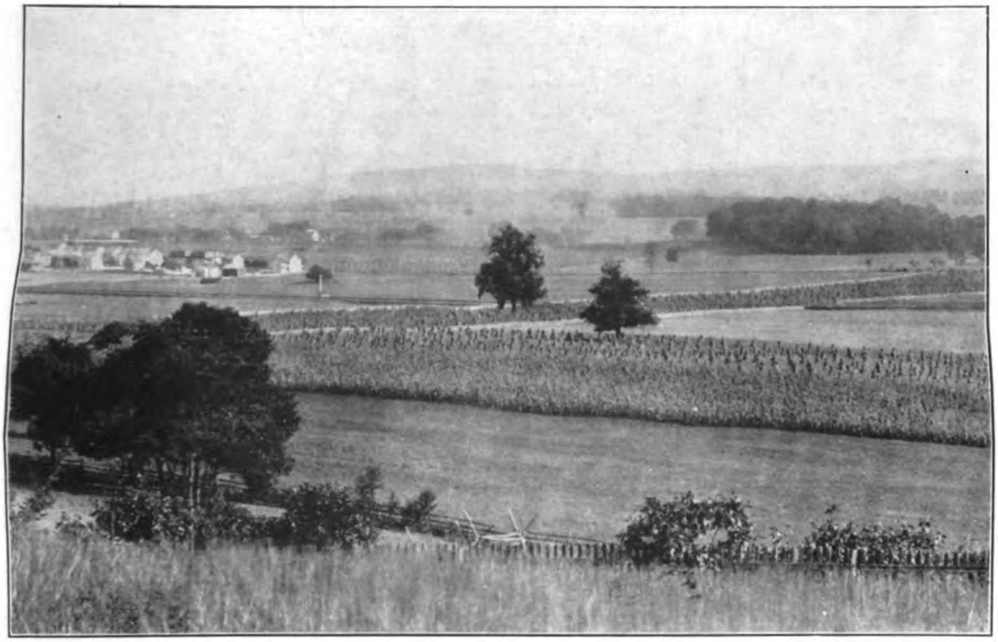


1. Planting plan for one sash only

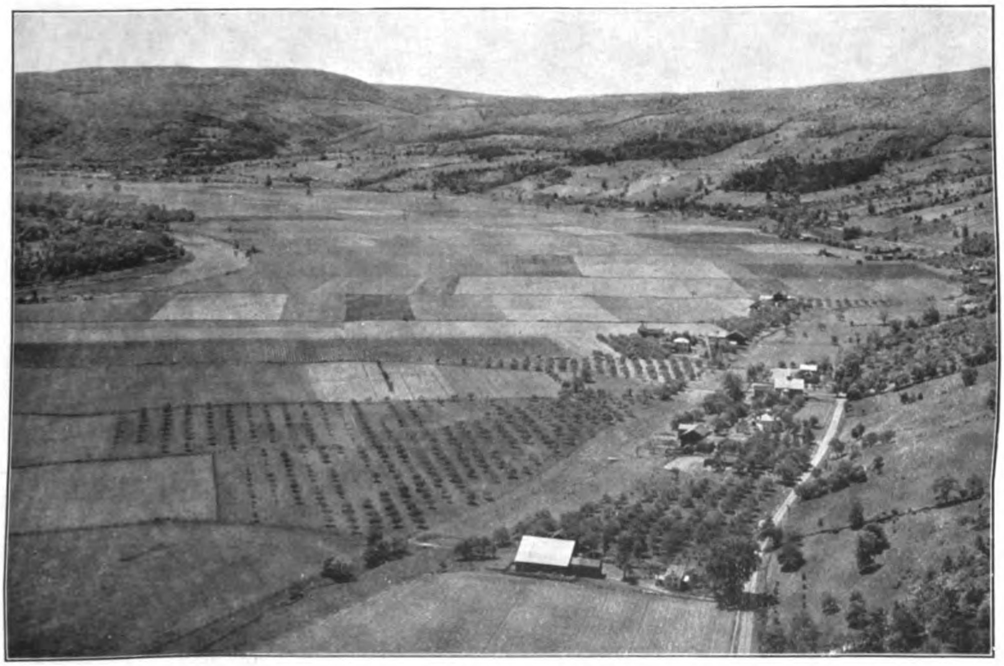
2. Where two sash are available the space can be used as shown here

FIG. 193. Planting plans for 1- and 2-frame hotbeds, designed to give the best use of all the space with regard to the needs of the home garden

Before sowing any seed rake the whole surface thoroughly to kill weed seedlings. From now forward give daily attention to watering the seeds and seedlings, airing the beds, and closing them at night. In mild, sunshiny weather between, say 9 and 4 o'clock, sashes may be raised by 2 x 4-inch blocks, according to the amount of air needed, otherwise the plants will "cook." Covering with mats, shutters or old quilts during cold nights is also necessary. Tepid water applied in a fine spray is best for watering during cold weather. Never let the ground become dry. From the hotbed, seedlings may be transplanted to cold-



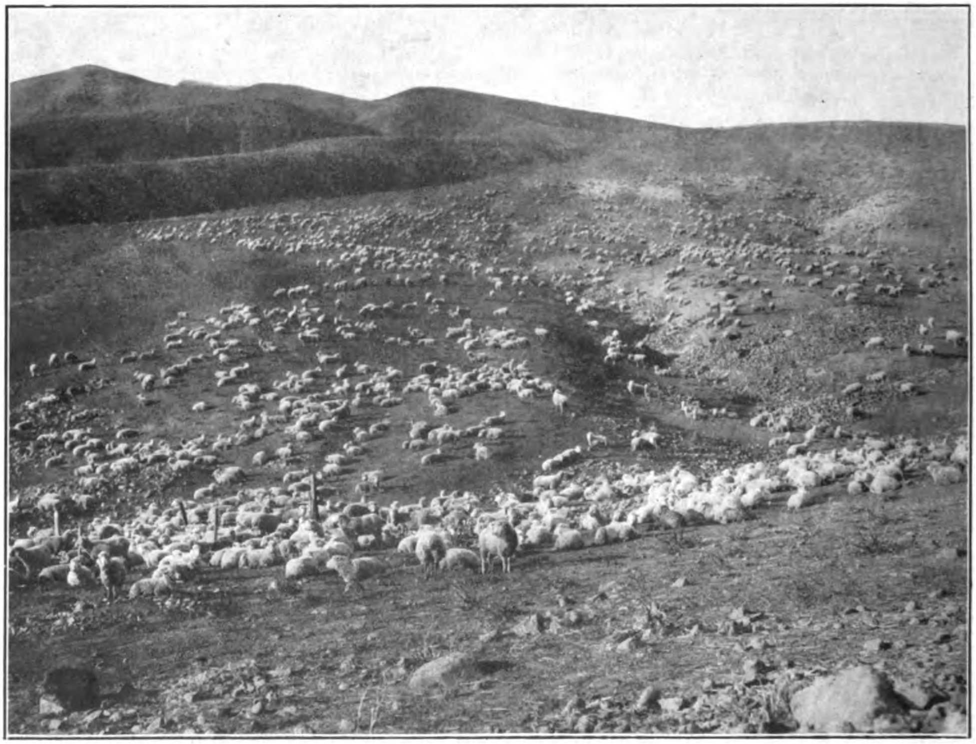
A broad, level, fertile valley in southeastern Pennsylvania bearing all the earmarks of successful, progressive farming. (U. S. Bureau of Soils)



A narrow, mountain-flanked valley in southcentral New York, where good farming and a deep, rich soil have kept generations of farmers prosperous

GOOD FARMING TILLS THE LEVEL FIELDS AND LEAVES THE UPLANDS AS PASTURE FOR STOCK WITH WHICH TO MAINTAIN THE FERTILITY OF THE LOWLANDS

The product of the forests on a single project in Washington state (U. S. Reclamation Service)



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Some land that can never be tilled can yet support stock, and gradually improve in doing so

IN THE PACIFIC NORTHWEST, FARMING IS STILL IN SOME DEGREE A FRONTIER STRUGGLE

frames for hardening off. After the hotbed has yielded its crop of plants for the coldframe (such as cabbage, cauliflower, egg plant, pepper, tomato, lettuce, etc.) it may be used for a second sowing of cucumbers, melons, tomatoes, peppers and egg plants to be later set out at regular garden distances in the open ground.

FIG. 194. Don't sprinkle vegetables; soak the ground deep

Where vegetable growing is an important feature of the farm work, permanent hotbeds with concrete, stone or brick walls are economical. Of course any hotbed gradually becomes a coldframe as the manure stops fermenting and loses its heat. Thus the same bed may be used early in the spring for starting plants and later, and in the fall, for hardening or protecting them.

Early sowing. The use of hotbeds and coldframes permits better use of a small area, better care of both soil and plants, better root systems and often better crops. It is important that all such plants be "hardened off," that is gradually accustomed to the colder conditions of the outdoors before being set in the garden. They must also be transplanted once or twice from the seedbed in order to become "stocky," that is, short, stout and with plenty of feeding roots. Should long stems develop, they may be buried deeper since most plants will develop roots from them. Stockiness, vigor, hardiness, disease-resistance and good roots are best secured by comparatively low temperature, ample ventilation, almost scanty watering, and full sunshine. Hardy or cool-weather vegetable seeds may be sown, or properly hardened off plants transplanted to the open ground even before the period of light spring frosts has passed. These include asparagus, beet, broccoli, Brussels sprouts, cabbage, carrot, cauliflower, celeriac, celery, chard, corn salad, cress, endive, kale, kohl rabi, leek, lettuce, onion, parsley, parsnip, peas, potatoes, radish, rhubarb, salsify, spinach, turnip, and witloof. Tender or warm-weather vegetable seeds should not be sown out of doors or even hardened-off plants set in the open until after the ground has become warm and the weather thoroughly settled. These sorts include beans, corn, cucumber, cantaloupe, eggplant, okra, pepper, pumpkin, squash, sweet potato, tomato, and watermelon.

Transplanting. When seedlings are to be transplanted to the garden, the soil should be moist and in prime condition. Plants do best if the work is done in the evening in cloudy weather or just before a shower. Properly hardened cold-loving plants, such as cabbage and its allies, may be set as soon as the ground can be worked; heat-lovers—tomato, pepper, eggplant, melons, etc.—not until danger of frost has passed. Soak the soil half an hour or so before the seedlings are to be moved. Then take each one up with a ball of earth, keep it moist while out of the ground, set as soon as possible, and cut off a couple of its largest leaves to prevent its giving off too much moisture until its root system is newly established.

Cultivation. Cultivation during the growing season is given to keep down weeds and to maintain an inch or so of loose soil on the surface. This keeps the soil moisture down where the roots can get it instead of letting it rise to the surface and be rapidly lost by evaporation. The garden rake used freely but lightly all over the bed until the seeds sprout will kill many young weeds. After the plants appear, the rake attachment on a wheel tool should be run close to the rows until it interferes with the plants, then the hoe attachments may be used. All the space between the rows should be cultivated until the plants shade the ground or become large enough to prevent work. This will make mulching unnecessary although a coat of coarse manure, straw or lawn clippings may be spread between the rows if desired. Tomatoes and celery are often mulched in this way.

Cover crops. As autumn approaches, a cover crop, preferably a hardy one, should

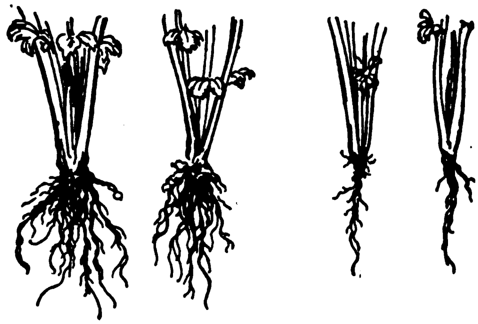


FIG. 195. Most plants benefit from being transplanted; the celery seedlings at the left were moved twice, those at the right of the same age, not at all.

be sown broadcast among the maturing crops. Even though much of this may be destroyed in later harvesting work, enough will live to make it worth while. After harvesting is done, the whole garden should be completely cleaned and the refuse either burned or added to the compost heap.

Irrigating. Water is often needed. The best way to apply it is usually by overhead irrigation (Chapter 3 and Volume III). The next best way is by furrows. Hose sprinkling

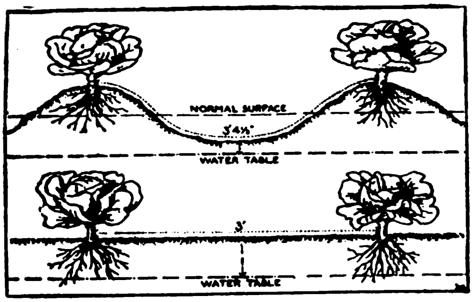


FIG. 196. Except on undrained or undrainable land, level cultivation (*below*) is a much better practice than hilling or mounding (*above*).

is usually worse than useless because the water does not go deeply enough. Better to soak the soil well a foot or two deep and then give nothing for 2 or 3 weeks, than to apply the same amount of water in daily installments. Watering should be done in the evening so the foliage will be well dried by morning. Midday watering does no harm, but because of evaporation it demands more water, especially in warm sunny weather.

Special work during the growing season, such as training, pruning, control of pests, blanching, etc., is discussed under the various vegetables (Chapter 28). In the cold parts of the country, the tender crops may need protection in case of late spring and early summer frosts. Among the best ways to give it are (1) to stir the ground between the rows just before nightfall so the air will become filled with moisture which will be deposited as dew; (2) to cover the plants with earth, straw, paper, cloth, etc.; (3) to spray the plants and a border of several yards around them at dusk, or before sunrise, but preferably both evening and morning. The evening sprinkling helps prevent frost damage, the morning treatment "draws" the frost if not too severe.

Using the vegetables. No gardener should be content to obtain only a summer supply of vegetables for his labors. With but little extra labor enough can be stored, put up in glass or tin containers, or dried, to make the purchase of vegetables unnecessary all winter. The last two activities come in the farm woman's field, and either the local county Advisor, the State College or the Federal Department of Agriculture will tell her how to do the work successfully.

Vegetable storage may be an outdoor proposition in which pits covered with straw and earth are employed; or it may mean the use of house or barn cellars, or the construction of a special root cellar or cave. The necessary conditions for the storage of the different crops are noted in Chapter 28; valuable suggestions are also given in Farmers' Bulletin 879. As in all storage operations, only sound, firm products should be kept; when spoiling once starts, it spreads rapidly. Late crops of the typical winter vegetables such as potatoes, turnips, beets, parsnips, onions, etc., can of course be kept most of the winter with but little loss of quality. Some of this class, notably beets, carrots and a few others, are much more delicious, however, if harvested while small, young and tender, and put up in jars or cans.

While the properly planned farm and home garden aims to supply only the family needs, yet it may often provide a further surplus that might better be sold than wasted. Only the best quality products should be offered for sale and these in prime condition. Lower grades should be either prepared for the home table, made into pickles and canned goods or fed to animals. The demand for such homemade goods is always greater than the supply.

PLANTING TABLE FOR A GARDEN (*See Opposite Page*)

(In a suggestive plan like this dates can of course be only approximate. Those given are for the latitude and climate of Long Island. In general every 100 miles north or south means a week later or earlier; likewise a change of 100 feet in elevation means a variation of about a day. Since Long Island is about at sea level, changes in altitude on a line with or north of this section could only make the dates later. In the same way the amount of any one vegetable needed for any particular family can be decided upon by that family only, or some one who knows its likes and dislikes. At best such a table can only be a ground work for each gardener's plans.)

PLANTING AND SEED TABLE FOR THE HOME VEGETABLE GARDEN

(Adapted from Mich. Bulletin 4 for conditions like those in Southern New York. *a*—under glass; *p*—plants; *h*—hills)

VEGETABLE	WHEN TO PLANT			DEPTH TO PLANT (inches)		ROWS APART		PLANTS APART (inches)		FOR 100 FT. ROW		USE AFTER PLANTING (days)	SEEDS IN 1 OZ.	% GERMINATION IN 1-YR. SEED	YEARS SEED CAN BE KEPT
	First Crop		Second Crop			Cultivation		In							
	Seeds	Plants		Out doors	Under glass	Horse (feet)	Hand (inches)	Hills	Drills	Seeds	Plants				
Beans, bush...	Apr. 15–May 1	May 1–31	June–July 20	1–2	½	2½–3	18–30	8–12	3–4	1–2 pts.	100–150 (*h*)	45–65	200–250	90	3
Beans, pole and Lima.......	May 1–15	May 15–31		1–2	½	3–4	24–36	18–30	5–6	1 pt....	35–65	50–80	150–200	90	3
Beets........	Apr. 1–15	Apr. 15–30	May–Aug.	¼–½	¼	2½–3	18–24	.....	2–3	2 oz....	80–100	60–85	1,500	140	4
Brusselssprouts	Feb. 15–Mar. 1 (*a*)	Apr. 15–May		....	¼	2½–3	18–30	18–24	.....	¼ oz....	50–75	95–120	....	90	3
Cabbage, early..	Feb. 15–Mar. 1 (*a*)	Apr. 1–15		....	¼	2½–3	18–30	12–18	.....	¼ oz....	50–90	90–105	8,500	90	3
Cabbage, late..		May	June (*p*)	....	¼	2½–3	18–30	18–24	.....	¼ oz....	50–75	100–150	8,500	90	3
Carrots.......	Apr. 1–30			¼–½	...	2–2½	18–24	.....	3–4	½ oz....	....	75–110	20,000	80	1
Cauliflower....	Feb. 15–Mar. 1 (*a*)	Apr. 15–May 1		....	¼	2½–3	18–30	18–24	.....	¼ oz....	50–75	100–130	10,500	80	4
Celery, early..	Feb. 1–15 (*a*)	Apr. 15–May 1		....	¼	2½–5	18–30	.....	4–5	¼ oz....	250–300	120–130	20,000	60	2
Celery, late ...	Mar. 15–Apr. 15 (*a*)	June 20–July 15	June–July 15	....	¼	3–5	18–60	.....	5–6	¼ oz....	200–250	130–150	20,000	60	2
Corn, early....	Apr. 15–30	May 1–15	June–July 15	1–1½	...	2½–3	24–36	18–24	8–10	¼ pt....	50–65*h*	65–90	....	85	1
Corn, late	May 1–15		June–July 5	1–1½	...	2½–3	24–36	24–36	10–12	¼ pt....	35–50*h*	75–100	....	85	1
Cucumbers....	May 1–15	May 15–31	June–July, 15	½–1	½	4–6	48–60	48–60	12–18	½ oz....	80–100 (*h*)	60–80	1,000	85	5
Egg plant.....	Feb. 15–Mar. 1 (*a*)	May 20–31		....	¼	3–4	24–36	24–36	.....	¼ oz....	25–50	150–160	7,000	75	5
Endive.......	Apr. 15–30		July–Aug.	¼–½	¼	2½–3	12–18	.....	8–15	1 oz....	75–100	90–130	18,000	85	2
Kale.........	Apr. 15–30		July 15–31	¼–½	...	2½–3	18–30	.....	6–8	¼ oz....	80–150	90–120	8,500	90	2
Kohl-rabi.....	Apr. 15–30	May 1–15	June 1–30 (*p*)	....	¼	2½–3	18–30	12–18	4–12	¼ oz....	120–150	60–80	8,500	90	3
Lettuce.......	Apr. 1–30	Apr. 15–30	July 15–Aug31	¼–½	¼	2½–3	12–18	.....	12–18	¼ oz....	100–300	60–90	23,000	85	4
Muskmelon...	May 15–31	May 20–31		½–1	½	4–6	48–60	48–60	.....	1–2 oz..	20–25*h*	120–150	1,600	85	5
Okra.........		May 15–31		....	½	2½–3	18–30	18–30	2–3	½ oz....	40–50	....	500	80	4
Onion, sets....	Apr. 1–30		June–Sept.	¼–½	...	2½–3	12–18	.....	1½–2	2½ qts..	....	25–50	....	...	1
Onion, seeds...	Apr. 1–30			¼–½	...	2½–3	12–18	.....	6–10	¾ oz....	....	130–150	7,000	80	1
Parsley.......	Feb. 1–Mar. 1 (*a*)	Apr. 15–30	June–July	¼–½	¼	2½–3	12–18	.....	3–4	¼ oz ...	120–200	90–120	....	70	1
Parsnips......	Apr. 1–15			¼–½	...	2½–3	18–24	.....	Drilled	½ oz....	....	125–160	7,000	70	1
Peas, early....	Apr. 1–15		July 15–30	1–2	...	2½–3	18–30	.....	Drilled	1 qt....	....	40–80	50–150	90	3
Peas, medium and late.....	Apr. 15–30		July 15–31	1–2	...	2½–3	24–36	.....	.....	1 qt....	....	65–90	50–100	90	3
Peppers......	Feb. 1–Mar. 1 (*a*)	May 15–31		....	¼	2½–3	18–30	15–18	.....	¼ oz....	65–80	100–140	4,500	75	3
Potatoes, early.	Apr. 15–30			2–3	...	2½–3	18–30	9–15	.....	8–10 lbs.	....	80–100	....	....	1
Potatoes, late..	May 1–15		June 1–30	4–5	...	2½–3	24–30	12–18	.....	8–10 lbs.	....	100–140	....	....	1
Pumpkins.....	May 1–20			1–1½	...	6–10	72–96	72–96	Drilled	1 oz....	12–15 (*h*)	100–140	....	85	3
Radishes, early.	Apr. 1–30			¼–½	...	2½–3	12–18	.....	Drilled	1 oz....	....	30–40	10,000	90	2
Radishes, medium and late	May 1–15		Aug. 1–31	¼–½	...	2½–3	12–18	.....	6–10	1 oz....	....	35–50	10,000	90	2
Rutabaga.....	Apr. 1–30		June	¼–½	...	2½–3	18–24	.....	3–4	1 oz....	120–200	75–100	13,000	85	4
Salsify.......	Apr. 1–15			¼–½	...	2½–3	18–24	.....	4–6	1 oz....	....	120–180	3,000	75	2
Spinach......	Apr. 1–15		Aug.–Sept.	¼–½	...	2½–3	18–24	.....	.....	1 oz....	....	30–60	2.500	80	2
Squash.......	May 15–31 (*a*)		June 15–30	1–1½	½	3–8	36–96	36–84	14–18	4 oz....	15–35 (*h*)	60–125	100–500	85	3
Sweet potatoes..	Apr. 1–30 (*a*)	May 1–20		....	...	2½–3	24–36	.....	.....	.....	65–75	120–130	....	....	1
Tomatoes.....	Mar. 1–15	May 1–30	June 1–30 (*p*)	....	¼	3–5	24–36	18–36	.....	¼ oz....	35–75	100–140	10,000	85	5
Turnips	Apr. 1–15		July–Aug.	¼–½	...	2½–3	18–24	.....	4–6	½ oz....	....	60–80	13,000	85	4
Watermelons..	May 15–31			½–1	½	6–8	60–72	60–72	....	3–4 oz.	16–20 (*h*)	100–150	125–150	85	5

FIG. 197. The product of two 12-year-old apple trees. The pile at right, from an unsprayed tree, contained not one sound fruit, that at the left, containing 560 perfect fruits came from a tree sprayed at a cost of 15 cents (O. Bulletin, 217).

CHAPTER 24

The Principles of Fruit Growing

By MAURICE G. KAINS, *formerly special crop culturist, U. S. Department of Agriculture, and Associate Editor of the "American Agriculturist;" later Professor of Horticulture, Pennsylvania State College; and at present Horticultural Consultant and Horticultural Lecturer, Columbia University, N. Y. As a teacher, author, and advisor in matters of practical fruit growing, Professor Kains has become widely known throughout the country.*—EDITOR.

FRUIT growing, as discussed in this cyclopedia, includes the production, handling and disposal of fruits cultivated in the United States and Canada. The plants include trees, bushes and vines, the fruits themselves are the edible parts produced by the development of the flower. Commercial fruit growing demands considerable business ability, capital, equipment, and knowledge. Its success also depends on relatively large areas being devoted to a few varieties. In raising fruit for home use, the capital, equipment and acreage may be small, but a large number of varieties should be grown to cover the entire season.

Commercially, fruit is grown in restricted areas where conditions are specially favorable. For instance, profitable apple growing extends from Nova Scotia to Michigan; southward in the Uplands to northwestern Georgia and the Ozarks; and from British Columbia to the mountains of California. Figs and other semi-tropical fruits are confined to a narrow belt between the states from Florida to southern California and the Atlantic Coast States as far north as Virginia. Strawberries are grown commercially in almost every state and Canadian province, the chief area extending from Louisiana to Michigan and Wisconsin; its harvest season moves northward at the rate of 100 miles a week. Home fruit culture has far wider limits because fruit may often be grown to perfection where large-scale production might not pay.

Controlling Factors

Climate is the chief limiting factor in all fruit growing. Each plant makes its own demand as to the temperature needed to develop its fruit properly. Latitude and elevation are somewhat akin, since plants like currants and apples which thrive in the cool north also succeed in the cool southern mountain districts, but fail in the southern lowlands. Lack of moisture in the air also limits fruit growing, as in the northern prairie states where trees often fail because of the dry winter air rather than because of the cold.

Location and site bear directly upon the behavior of a plantation; for while soil and other factors may all be favorable, if the place is frosty or rainy in late

spring or early fall or is windy during the ripening period, little or no fruit may be harvested. The great grape-producing areas are almost all close to large bodies of water which keep the temperature low in spring and relatively high in autumn, thus favoring production. In many cases, windbreaks prevent damage to plantations, especially just before and during harvest.

Transportation is important only when the fruit must be marketed, but as every farm orchard may at times produce more than can be consumed at home, it is always well to consider methods of reaching a market. A good road for either horse or auto truck is the first requisite. The smoother it is the longer it may be, because even easily bruised fruit can then be carried over it. When two or more competing methods of transportation—trolley, boat, railway, express and parcel post—or competing companies are available, the shipper has a big advantage.

Value of land may be the determining factor as to the kind of fruit grown commercially. Apples might not pay because they require years to reach bearing age, are relatively low priced and must compete with fruit produced on less costly land; whereas strawberries, because quick to bear and enormously productive under good management, may be profitable on costly land near cities. Moreover, locally grown berry crops command high prices because they reach consumers in better condition than those shipped far.

FIG. 198. Climate and locality are all-important factors in successful fruit growing. The famous "Apple Pie Ridge" in West Virginia. (U. S. Bureau of Soils.)

Knowledge and experience on the part of the grower are, at the start, of less importance than is popularly supposed. Certainly, they help immensely in the race for successful market production; but since the general farmer's fruit-growing goal is neither a livelihood nor wealth, but rather a well-supplied home table, every one who owns or rents land and who will follow the suggestions of successful growers may enjoy the prospect of success, even though his initial ignorance may cause him to make some mistakes. Moderate priced books on almost every fruit crop that can be cultivated in North America are now available. Some of these should be in the library of every man who owns land suitable for fruit growing.

The investment necessary for home fruit production, aside from the value of the land, includes the cost of the trees, plants, tools (mostly those used elsewhere on the farm and in the vegetable garden), fertilizers, spray mixtures, and other materials used on the land or the plants. The labor investment is somewhat greater than that required by the cereals and hay, but usually less than that demanded by potatoes and corn. Much of the work, coming when other tasks are not pressing, is not felt. But the returns in value and variety of food are far higher than those of almost any other farm crop.

The Home Fruit Garden

The soil. Peaches thrive best on sandy soils, pears and currants on heavy ones, blueberries on acid ones, and so on. Commercial fruit growers try to place each class on a soil that suits it. Nevertheless, the farmer who wants fruit but who lacks the ideal soil for any

FIG. 199. Clean cultivation until a cover crop is sown in midsummer is good practice where the land is not too sloping.

one kind need not hesitate to plant on whatever he has; for the great majority of fruits do well on any soil properly drained and reasonably fertile. Deep loams with porous subsoils are generally best for all tree and bush fruits. Shallow soils should be avoided especially for deep-rooting trees, both because their stock of plant food is soon exhausted and because the roots, being near the surface, permit the trees to suffer during dry, frosty and windy seasons.

Cultivation. Plowing should always be as deep as possible and may well be followed by the subsoiler. Disking manure and cover crops into the surface before plowing helps greatly to fine heavy soils. Heavy land should be fall plowed and left rough over winter so that frost action will improve its texture. It may then be handled much earlier in spring than unplowed land or land fall plowed and immediately harrowed. Harrowing or cultivating between rows must always follow plowing and be repeated every two weeks or oftener until midsummer when a cover crop is sown. This "clean cultivation" not only kills weeds but also conserves moisture in the soil. It is the general practice. Sometimes, however, a "sod mulch" is employed, the land being seeded to grass which is cut regularly and placed around the trees to rot. It is useful only on hilly land and where soil water cannot be easily removed by drainage, the grass or clover serving to pump it out of the soil. In addition to the objection that the grower may be tempted to make the grass into hay, thus robbing the soil of fertility as well as water, there is the constant danger of damage being done to the trees by mice which build nests in the litter and gnaw the bark from the trunks.

Feeding. Fertilizers are best applied to the cover crop (see below). Thus they do double work first by making the cover crop larger so that a greater quantity of vegetable matter may be plowed under; and second, by gradually returning to the soil as decay proceeds. Nitrogen must not be supplied in excess or the plants will become sappy, and fruit production will be impaired. If the foliage is a healthy green, little or no nitrogen is needed; if yellowish, more is called for. Manure may be applied freely unless the soil is already rich and the foliage indicates plenty of nitrogen. There is no danger of applying too much phosphoric acid or potash. These do not injure the trees and, being taken up and held by the soil in the form of compounds, they are not lost from the soil by drainage. Lime, while not itself a fertilizer, tends to set free plant food "locked up" in the soil. It may therefore be applied liberally once every 3 or 4 years (Chapter 8).

Mulching, except as noted above, is rarely done in orchards. It is widely employed in berry growing. Raspberries and other bush fruits are greatly improved by straw and litter mulches applied after spring plowing and cultivation. Strawberries are mulched just before winter to prevent heaving of the soil as it alternately freezes and thaws. In spring, such mulches are raked off the plants between the rows. After harvest, mulches are generally burned or raked off and the soil loosened with plow or cultivator.

Cover crops are grown solely to benefit the fruit plants, never for direct sale or use. Usually they are annuals sown during midsummer and plowed under the next spring. Their principal functions are (1) to prevent soil washing in fall, winter and spring; (2) to check fall growth and thus ripen the wood; (3) to add vegetable matter to the soil; (4) to save plant food that might be washed away while the trees or shrubs are not active; (5) to add nitrogen, if leguminous, like Crimson clover, soybeans or cowpeas (this being the cheapest way to supply this element); they also (6) hold snow and leaves on the ground as a mulch; (7) save falling fruit from injury, and (8) prevent injury to the roots during winter. Always such crops must be plowed under while still soft and succulent; if allowed to grow tough and woody, they form a dry layer at the bottom of the furrow and prevent water from coming from lower levels; moreover they then decay and become useful to the fruit plants more slowly. The best hardy legumes are hairy

FIG. 200. Mulching strawberries. Don't put on the winter mulch until the ground is frozen

vetch, Canada field peas, and crimson and mammoth clovers; the best hardy non-legumes are dwarf Essex rape, turnips, and rye. Good cover crops that winterkill include buckwheat, cowpeas, barley, and soybeans all of which are more often grown as spring- or summer-sown green manures to be plowed under in early fall in time for the sowing of a winter cover crop such as rye. Thus two crops of vegetable matter may be secured in one year.

Arrangement. In planning the home fruit plantation, choose a good many of the best dessert and kitchen varieties, to cover the entire season, but few of each kind to prevent waste. The rows should run the long way of a rectangular field to favor horse cultivation, though tillage should be given both ways if possible. It is believed that a north and south row gives getter results than one running east and west, but this has not been proved. On sloping land the rows should follow around the slope. Always err on the liberal side and allow the greatest distances recommended between plants as this results in better fruit and more convenient handling. Small-growing trees may alternate with large ones, shrubs may be placed between the trees, and vegetables, strawberries, etc., between the shrub rows. But such a plan demands special care in cultivation, fertilizing and managing or the plants will suffer and the crops be inferior.

Planting. Fall planting offers 3 advantages: (1) a better chance of getting the varieties desired, nurserymen having better stock at that time; (2) trees are ready to start growth early in spring; (3) work is done when time is usually plentiful. Spring planting may avoid winter injury but it may be delayed so late that the plants do not get a good start. In ordering nursery stock for fall delivery, however, the buyer should insist that the trees be allowed to ripen fully before being dug and that no leaves

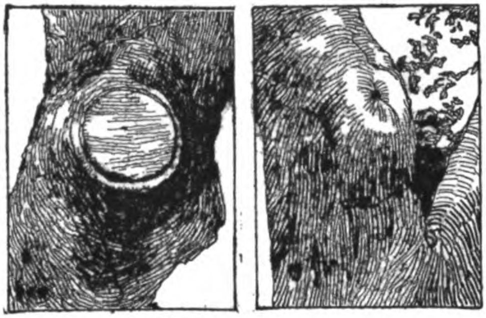


FIG. 202. Prune branches smooth and close to the parent limb and the wounds will heal clean and rapidly

be stripped or clipped off. Raspberries and similar berries should be spring planted because they are likely to winterkill unless well established; currants and gooseberries should be fall planted, because they take hold quickly and also because they start to grow very early in spring; strawberries may go in either in spring, midsummer or autumn. In planting trees make the holes large enough to take all the roots without serious bending, place the top soil around them, tramp it down firmly, place the sub-soil on top and tramp it down, too. Set the tree an inch or two lower than it stood in the nursery.

Pruning. Best fruit is produced by well-trained trees and shrubs (see Chapter 27). In general, the less pruning the better. When possible the work should be done while the parts to be removed are small. A correct knowledge of the positions and growing habits of blossom buds should always precede any actual pruning, otherwise loss of fruit may follow. About the only need for pruning young trees is (1) to prevent crossing of inside branches; (2) to encourage the development of limbs and twigs in blank spaces; and (3) to shorten branches that tend

FIG. 201. The use of a planting board assures the accurate placing of every tree

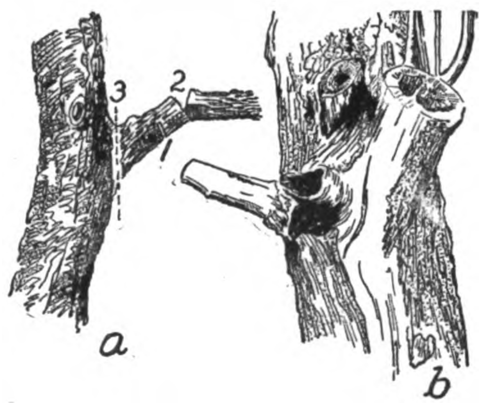


FIG. 203. *a* The right way to prune large limbs, by making cuts in the order given; *b* stubs left in pruning soon result in decay and death.

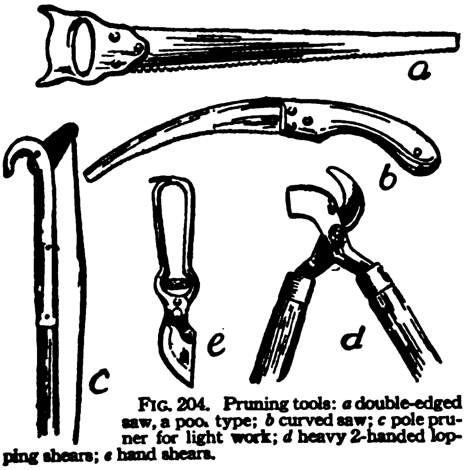


FIG. 204. Pruning tools: *a* double-edged saw, a poor type; *b* curved saw; *c* pole pruner for light work; *d* heavy 2-handed lopping shears; *e* hand shears.

to throw the tree out of shape. All pruning wounds should be made close to the part allowed to remain so healing will be favored. Large ones should be painted with white lead and pure linseed oil.

Spraying. Successful spraying depends upon correct knowledge of what is being fought as well as upon proper application of the spray. The operator must know whether he is fighting a curable or a preventable disease, a sucking or a biting insect, etc. Otherwise time and material will be wasted. (See Chapter on Spraying and articles on the various fruits.)

Protection. Protection against frost, especially during blossoming time, may often be secured by cultivating or harrowing just before night to fill the air with moisture; by smudging with smoldering (not blazing) damp straw, by irrigation, and by warming the air with coal, wood, or oil heaters. In the last case many small fires are better than a few large ones. While the cost of such protection may seem high, it may mean the difference between a total loss of fruit (perhaps foliage also), and success. When successful, the grower is likely to be the only one in a neighborhood or even a large district with a supply of fruit. He can therefore command prices high enough to pay him well for his outlay of money, labor and time in protecting his plantation. Protection against rabbits and mice is best secured with half-inch galvanized hardware cloth extending from 3 inches below ground to about 2 feet above. Other methods—wood splints, corn stalks, etc.—are less satisfactory because less safe and shorter lived. In some sections deer and other animals do great damage. When fencing is impracticable, the best remedy is a change of legislators so laws may be passed to protect such plantations.

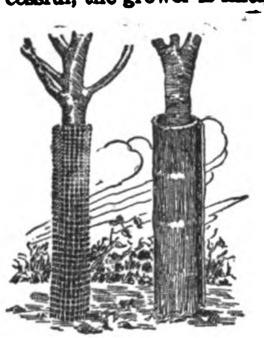


FIG. 205. Two types of tree guard: *a* wire netting: *b* wood veneer.

Irrigation. Irrigation is essential in arid sections to make any fruit crop grow; it is often helpful in humid climates to secure best results. In dry regions, the water is usually applied as in general farming, in checks or furrows, seldom by flooding; in humid sections these methods may also be used, but overhead sprays are probably more common as most of the crops so treated are the berries, especially the strawberry.

Harvesting. The time to harvest fruit for home use depends much upon the kind and variety, but less so than when it is destined for distant markets. Almost all kinds may be practically ripe before being picked. Personal customers may be supplied with such fruit usually at extra prices. Blackberries and their kin, grapes and many other fruits can be had in perfection only when they have ripened fully on the plants. Pears must be gathered a week or two before ripening to secure the best quality. Currants and gooseberries are often used while still green. Between these extremes are many stages which must be learned for each kind of fruit.

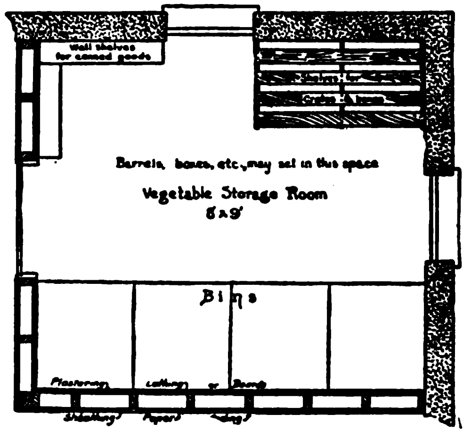


FIG. 206. How a part of a farmhouse cellar can be walled off for storing fruits, vegetables, and canned goods. Note double wall for insulation.

Storing. If fruit is to be kept for more than a day or two storage quarters are necessary. These will differ with the season and the kind of fruit. Any room or cellar suitable for keeping butter in summer will serve for summer fruit. Ice may or may not be used; generally it will not pay if much is needed. Fruit to be stored should be placed in the shade when gathered

and removed to cooler quarters soon after. It should be mature but not "dead" ripe. Late autumn fruit should be placed in frost-proof but cold, well-ventilated cellars or rooms, preferably separate from dwellings, and always without house heaters which often cause drying, shriveling and rotting.

Marketing. The best way to market surplus fresh fruit is to offer only perfect specimens. Good fruit always sells, even when the market is glutted with lower grades. As aids in selling, attractive packages often help. An advertisement in a city Sunday paper has often proved profitable by bringing one or two customers who then tell others how they were treated and thus widen the sales. The fruit and its condition when received by the buyer are the great advertisers.

Culls and by-products. Lower than best grade fruit should never go to market fresh. The demand for unfermented juices—grape, apple, raspberry, etc.—is steadily increasing. So is that for fruit sirups to eat with pancakes, waffles and fritters. For this purpose, the parings, cores, pits, etc., may be used. Much cull fruit is good enough for canning, preserving or making into "sauce" for which city people eagerly pay good prices. Some may be good enough to evaporate, but this method usually entails more work than the others. Also its products come into keener competition with those of commercial sources of supply. If these means of disposing of it fail, considerable low-grade fruit may be fed to the stock, perhaps with less profit, but at least with a prevention of loss.

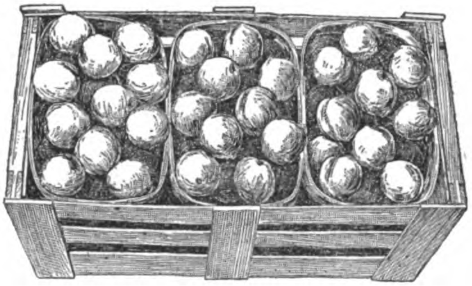


FIG. 207. A crate of well-packed peaches. The more tender the product, the more carefully it must be handled.

Fruit and other crops. The care of a one-acre fruit plantation need not interfere with, but rather should add variety to, other farm work. By proper arrangement the amount of labor necessary can be reduced to a minimum. Indeed, a good deal may be saved by combining other branches of farm work with it. Vegetable gardening fits in fairly well. But perhaps the best combinations are fruit and poultry, or fruit and bees, or all three. Chickens eat an enormous number of insects that would injure plants or fruit, and bees not only yield profitable honey and wax, but assist greatly in fertilizing the flowers, thus insuring good sets of fruit.

In fruit plantations, especially orchards, care must be exercised in the choice of intercrops. An ideal companion crop should be an annual, profitable either by direct sale or as stock feed. It should require cultivation, but not late stirring of the soil. It should not, like nursery stock, take the same kind of food from the soil. Preferably it should make its demands on the soil for water and plant food at a different season than the trees. Good crops include beans, squash, cabbage, turnips, mangels, late potatoes, truck, corn, and buckwheat; fairly good ones are currants and gooseberries, strawberries, asparagus, and rhubarb; poor, even bad ones are raspberries, blackberries, grapes, nursery stock, grain, and hay.

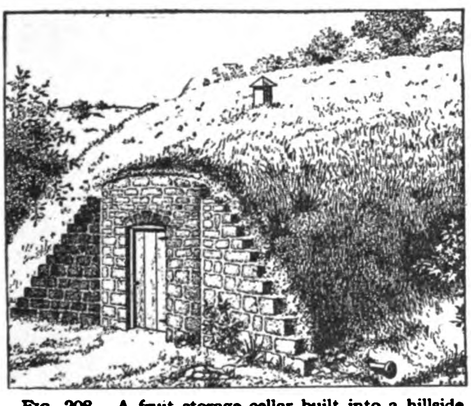


FIG. 208. A fruit storage cellar built into a hillside. Note warm air vent in the roof, and entrance pipe for cold air in the front, lower corner. (Farmers' Bulletin 879)

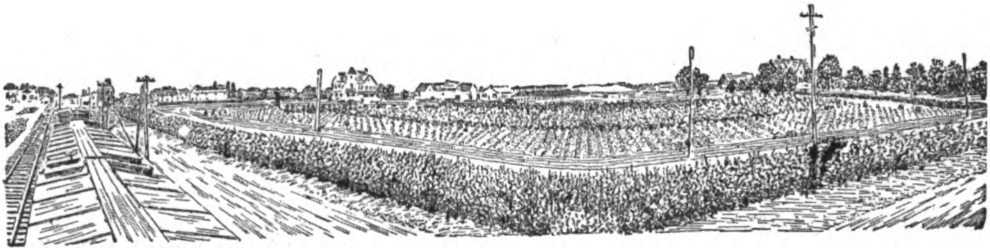


FIG. 209. General view of an extensive nursery well located and with excellent railway facilities

CHAPTER 25

General Principles of The Nursery Business

By SAMUEL FRASER, *Geneseo, N. Y., practical farmer, fruit grower and nurseryman. He came to America from England with a firsthand knowledge of the best British farming methods, which he has since developed, modified and enlarged into a broad, successful familiarity with the best practices in this country. His years at the Cornell College of Agriculture and his constant connection with that institution and its workers have kept his knowledge as up-to-date as it is sound and practical.*—EDITOR.

WHAT it is. The nurseryman's business consists of raising plants, shrubs, vines, trees, etc., of such varieties, in such forms and to such ages as the public demands. While the man who grows fruit and ornamental stock to plant out on his own farm follows the same general practices, he is not really a nurseryman until he begins to sell to outside customers. Thus far fruit trees have formed the larger portion of the output of American nurseries, and there is still a great call for this kind of stock. However, the production of ornamental trees, shrubs, and perennial herbaceous plants is becoming increasingly important, especially in the Eastern states. The growing of forest trees in the nursery has suffered from the competition of state conservation and forestry departments willing to furnish seedlings to residents at or below cost. Until recently the industry has suffered also from the dumping on to American markets of European surplus stock, which, raised where labor was cheap, could be produced and sold at figures far below those possible here.

The outlook. The introduction of diseases and insect pests in imported stock has caused so much trouble and loss that the government, through the Federal Horticultural Board, has put a stop to the importation of much foreign material. If this ban is not lifted, we may expect great improvement in the home industry, and the public may come to appreciate the fact that native, American-grown trees and shrubs are much better for American conditions than stock from Europe.

With the development of the industry in this country (for it is still a young and changing one), will come a louder call for special varieties for particular locations, and even for selected strains raised from selected, individual plants. This will probably become one of the most important phases of the business. A century ago men bought seedling apple trees or planted seed that was bound to produce trees of unknown character, just as English walnuts are now being planted in many places in the east and, 30 years ago, were planted in California. Then came a change and men wanted named and known varieties—Baldwin, McIntosh and Twenty Ounce apples, Mayette walnuts, etc. To-day, when it is recognized that not all Mayette walnuts are equally valuable, there is a call for the Wiltz Mayette, that the trees sold be budded from a certain tree of special merit, etc. The growth of this practice rests with the fruitgrower.

Extent and distribution. According to the latest census figures, the industry is fairly well distributed over the country, with New York, California and Texas in the lead. The first two hold their positions because in them fruit production is of great importance, and nurserymen have located near where trees are required. However, the tendency in New York

is toward an increase in the acreage of ornamentals and a corresponding reduction in that of fruits.

In 1909 there were 80,618 acres devoted to the growing of nursery stock, showing an increase of 35.5 per cent during the preceding 10 years. The value of products sold was $21,050,822 in 1909 as against $10,123,873 in 1899, an increase of 108 per cent. This business is in the hands of relatively few men; 98 per cent of the total nursery business was done by 2,470 establishments, with investments averaging $8,348. This is not strange for it is a very expensive business to enter, and full of risk in every way. Because so few are engaged in it and so many are dependent upon them for supplies, legislation is frequently enacted to compel nurserymen to conform to the ideas and desires of their customers.

Factors That Control the Nursery Business

Climate is a very important factor in controlling the type of stock produced. In southern California and Florida there are offered the citrus fruits, figs, avocados and other plants adapted solely to southern locations; farther north, in the cotton states, we find many trees and shrubs adapted not only to the immediate vicinity, but also to more northern states. In other words, we have entered a region of greater diversity. Still farther north the propagation of plants is limited by weather conditions and none but hardy types can be grown; hence the northern nurseryman must emphasize the fact that his stock is developed for his immediate locality.

Location. If one plans to become a distributor and to purchase supplies from all points (and this is a very important line of effort), the main question is whether to locate in the central part of the United States from which one can reach all sections of the country and try to develop a large, general business; or to locate near some dense centre of population and develop a local business, which is an entirely different proposition.

FIG. 210. One of the wild grapes of North America, illustrating an unimproved form. (This and Fig. 211 from "The Grapes of New York.")

FIG. 211. "America," an improved variety illustrating the results of plant breeders' and nurserymen's efforts. Drawn to the same scale as Fig. 210.

There are openings in both lines, but generally speaking, most men who distribute, purchase their supplies from a wholesaler who produces, for few men are able to produce all the stock they can sell.

Another important reason for choosing from among a few special localities (other conditions being equally favorable) is that the labor supply there has become accustomed to the work. For labor is a very large factor in the total expense and must be well trained and efficient.

Transportation, especially freight service, is a factor of growing importance. Quick delivery must be assured or express, with its higher charges, must be employed. This means location on a first-class railroad where plenty of cars and adequate service can be secured.

Site. The nurseryman locates with the production of a particular crop in mind and must, therefore, consider soil as well as climate. Each type of fruit or other plant requires a special combination of conditions in order to do its best. It is necessary to choose land that can be efficiently worked and that is as free as possible from destructive diseases and insect pests.

Land values. It costs so much to put poor land in good shape, and the land is, after all, so small a proportion of the entire investment in a nursery, that the choice of good land well located is more important than the saving of a few dollars per acre. That is, a nursery business justifies paying a higher price than most other lines of agriculture. However, in producing the cheaper materials such as apples and peaches on a very large scale, and especially in the South, every item counts,

and land of relatively low value, if suited to the purpose, is often used.

Knowledge and experience are essential to a successful nursery business and if they cannot be obtained gradually, in a first-hand way, they must be paid for. A considerable degree of organization is also necessary in a commercial enterprise. There are organizations which attempt mainly to grow some of all the kinds that will thrive in their immediate locality. However, the general tendency is for some men or firms to specialize in the wholesale production of certain few things, such as strawberry plants, cherries or peaches. This necessarily makes a perilous business, for if these few lines are overdone, the resulting glut may cause failure; and there is no second, reserve line to fall back on.

Capital required. The necessary investment both in money and in time is considerable. Ordinary trees are never ready for sale under 3 years, and often not under 8 or 10. Therefore capital must be on hand to support the business in the meantime. Frequently it will take 10 years of hard, constant work to establish a reputation; many successful enterprises have taken 15 to 17 years in becoming really established; those men who have succeeded have been mostly those who were able to wait and weather the storm for 20 years or more.

Moreover the necessary expenditure is rapidly increasing. Census figures show that the average value per acre of the nursery stock of the United States increased from $170.17 in 1899 to $261.12 in 1909. But whereas 10 years ago $250 per acre might have been enough to start a nursery, if one had the land, to-day it would take $400 or more to get the same results.

The preparation of the land must be thorough and often involves tile drainage; manuring and cultivation must be generous and also intensive. The investment in seedlings and young plants is often heavy. The equipment required is neither very complicated nor very expensive, but the expense for labor and for its proper, thorough training is usually heavy. The outside work must be under, and in the hands of, men who can be trusted, for a mistake in propagating or in naming a variety jeopardizes the reputation of the entire establishment. Three or 4 classes of foremen are generally needed to take charge of the different divisions, with a superintendent over all. A sales department with a proper selling force is essential for considerable ingenuity is required to get rid of the stock in time, and a capable advertising, accounting, delivery and collection department is needed in each sales division.

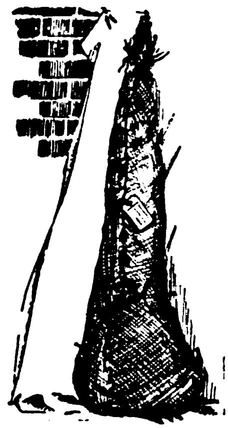


FIG. 212. A bundle of trees as received from the nursery. The health certificate tag is an essential detail.

The other most important department is the packing house; its foreman is responsible for the proper filling, packing and delivery on time of all orders, and also for the care of stored stock. When 2 or 3 men attempt to cover the whole field of growing and selling nursery stock, as is commonly done in small establishments, the work is done only under serious handicaps.

Nursery Management

The soil and its care. The soil must have thorough drainage but also be able to hold sufficient moisture. If it needs enriching, cover crops may be grown and turned under for 1 or 2 years, and manure added at the same time. No rotations are suggested because usually, after a crop of trees is grown, the land is turned over to farming for a while, so that its supply of organic matter and its texture may be brought back to normal. It is often necessary to dig the trees and work on the land when it is so wet that its texture is injured thereby. It is this possibility rather than the amount of plant food removed by the trees that explains the prejudice against renting farm land to nurserymen except for a very high rental.

Constant cultivation throughout the season is the general practice for the trees must be kept growing rapidly. There is no place for cover crops or mulching, unless it be a dust mulch.

In starting the business one needs to plant but one third of the acreage he expects to maintain the first season; the second year a like acreage should be planted, and the third year somewhat less will probably do. It is wisest not to use the same land for the same kind of trees oftener than once in 10 years, so that a farm, attached to the nursery, is needed to take care of the idle land and bring it into condition be-

tween times. Tree rows are run north and south unless the lay of the land prevents.

Seasonal care. In growing fruits either home grown or imported seedlings must be planted. Foreign material frequently arrives in December or January and is held in storage until planting time in April. In the meantime the plants are examined, any defective or injured roots are cut off, perhaps the tops are reduced, and probably the shipment is regraded so that when planted one block will contain nothing but first size stock.

The plants are set carefully in rows, as straight as possible, so that they may be cultivated mainly with horse tools. They are hoed 2 or 3 times a season and thoroughly tilled which may mean a cultivation every week.

If to be budded, stock is worked during the summer. In selecting the varieties to use the nurseryman has to use his judgment, for the plants will hardly go on the market for 2 or 3 years and he has to guess what the public will want then. The type of budding will depend upon the kind of plant. The land is usually prepared for winter by throwing some soil toward the plants to make furrows and permit water to move off when the ground is frozen or in periods of excessive rain. During late winter the budded stock is trimmed, and the following season the new tops which grow from the buds are encouraged by constant cultivation and training. That fall they may receive some pruning to improve their shape; then they may be grown another year to make proper size.

Insects and diseases. Spraying or dusting may be required to protect the trees from the aphis or other pests. The writer believes that this problem can best be handled by dusting, using a gasoline-engine-driven duster carried on a stone-boat hauled by a team of horses. Diseased nursery stock cannot be sold, and if serious diseases occur, they may force the nurseryman out of business. Most states require inspection before stock is sold or moved, and in many cases fumigation is insisted on before stock leaves the premises. Until recently but little attempt was made to control any of these serious nursery diseases.

Selling. When ready the trees are dug either with horse or mechanical power. The usual digger consists of a U-shaped blade on a very stout frame to which an 18 or 20 horse team or a cable leading to the drum of a steam engine, is attached. The usual practice is to dig a whole block in the fall, and store the trees. During the winter they are counted and graded according to the rules of the Nurserymen's Association. Standard rules as to sizes have been adopted in the case of most fruits and an attempt is being made to establish rules to cover ornamentals. In some cases the trees may be tiered up in bins as high as the roof; in others, each tree lifted with a ball of earth and kept in sand all winter; in still other cases trees are left in the field all winter and dug as required.

Fig. 213. Two-horse tree digger for nurseries

The business has so many angles and is carried on in so many ways that only a rough survey is possible here. It is only recently that cold storage has been used, and this is done in the South only. In the North frost-proof houses are used; when the warm weather comes in spring, the stock begins to grow, so that by June first everything left unsold is either taken out and burned or put back into the ground to be sold later on as transplanted stock. This system has developed an extremely wasteful policy, by which millions of trees are burned every year, either because the variety is not popular, because there is an oversupply, or because the public has been educated to demand a tree of a certain age only. The attempt to get rid of surplus stock by quoting a much lower price after May has done more to injure the industry than anything else.

In general, business methods are lacking in the nursery industry. Trees are often sold

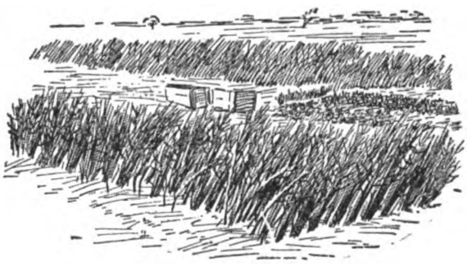


Fig. 214. Nursery stock "heeled in" over winter ready for early spring shipment

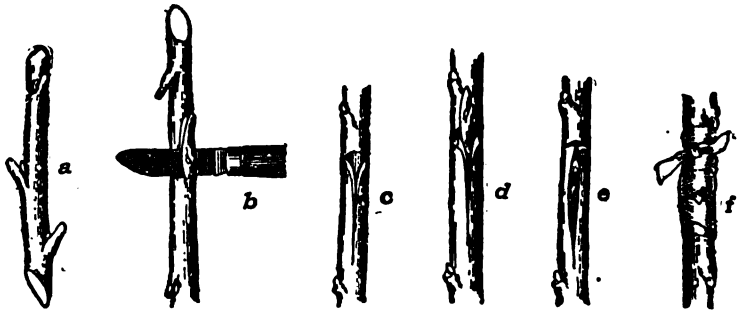


FIG. 214*a*. Six steps in budding: *a* twig carrying buds; *b* cutting a bud; *c* stock with slit cut for bud; *d* inserting the bud; *e* the bud in place; *f* the bud tied with raffia

regardless of cost; in fact, few nurserymen know their cost figures, although most of those engaged in the industry know they have not made any money during the past few years. There is need for much pioneer work in determining the fundamentals of the whole industry and what the procedure costs; there is need for a better system of advertising its products; there is need for a better means of determining what the public will require in the future.

The Relation of Nursery Work to Other Farm Work

If, as suggested above, a farm be attached to the nursery, it must take second consideration, for the nursery work is expensive, it is urgent, and its results are of much more consequence than those of the farm. A certain amount of haying can be done with advantage since it usually occurs at a time when the nursery help is not busy; and undoubtedly a few crops could be worked in, which would not seriously interfere with the requirements of teams and help for the nursery work. But it is far better to confine any such farming to the growing of crops and not attempt to put in any livestock. In a few instances orchards have been planted alongside nurseries, more for the purpose of advertising the nursery, than anything else and where this is done the fruit business must be run as an absolutely independent activity. The orchard is a good place from which to secure buds for the nursery, and it enables one to be sure that he is propagating from trees that are true to name. Also if careful crop records are kept, it enables one to propagate from trees of known value. But it will *not* do to try to run fruit-growing and the nursery business with one staff; something is bound to suffer.

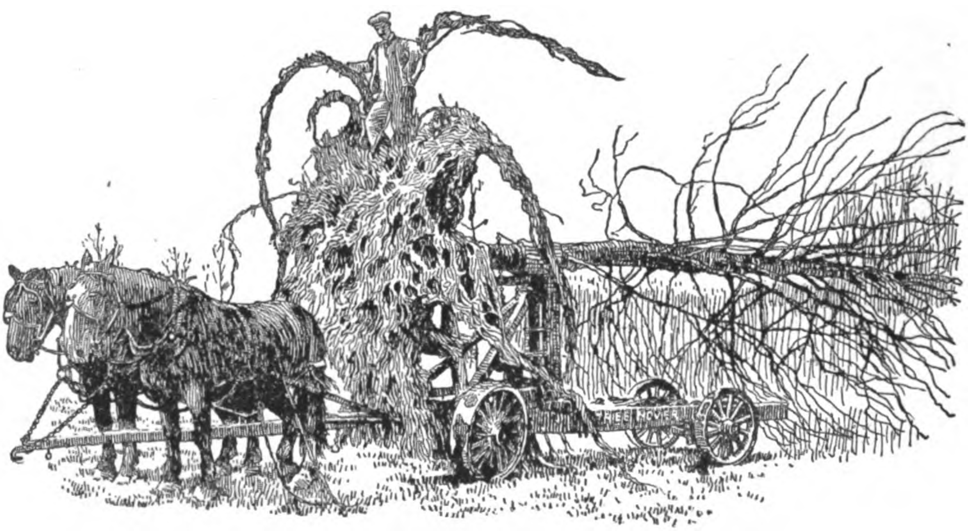


FIG. 215. Some nurserymen have made a specialty of selling and moving big trees, which involves new methods and new machines

FARM KNOWLEDGE

VOLUME II—PART IV

How To Grow Crops

THE exact methods to be followed in growing any crop depend to such an extent upon local conditions and variety preferences that complete cultural details to fit all possible circumstances would require a volume for each crop. There are, however, fundamental operations that can be applied with but slight modification, wherever a crop can be grown; these, and the general statistical facts that the practical farmer is most likely to find interesting and valuable, make up the five chapters of this part of FARM KNOWLEDGE. Practically all reference to insect pests and plant diseases is omitted, since plant enemies, the injury they do, and the means by which they can be controlled, are fully treated in Chapters 32, 33, 34, and 36 (Part V). Similarly the improving of crops by the production and selection of new varieties, etc., is left for Chapter 31. The methods recommended are in every case based upon time-tried, successful practices, and carry as well the seal of approval of scientific investigation.—EDITOR.

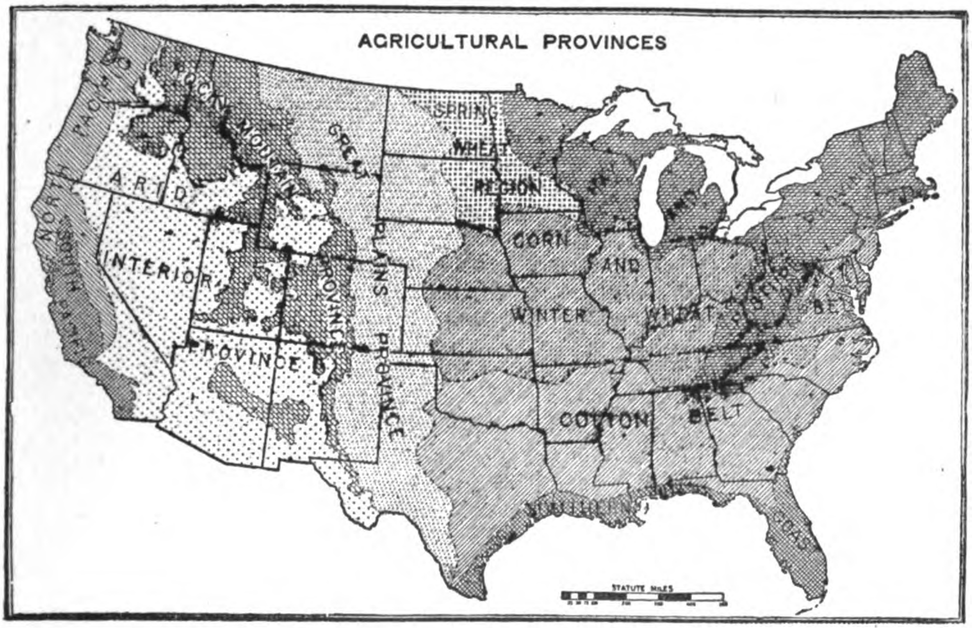


FIG. 216. The principal agricultural sections of the United States. Compare them with the sections described in the foregoing chapters, and the map as a whole with the maps showing the distribution of livestock in Volume I, the value of farm land (p. 97), and distribution of the various crops, on pages that follow. (1915 Yearbook, U. S. Dept. of Agr.).

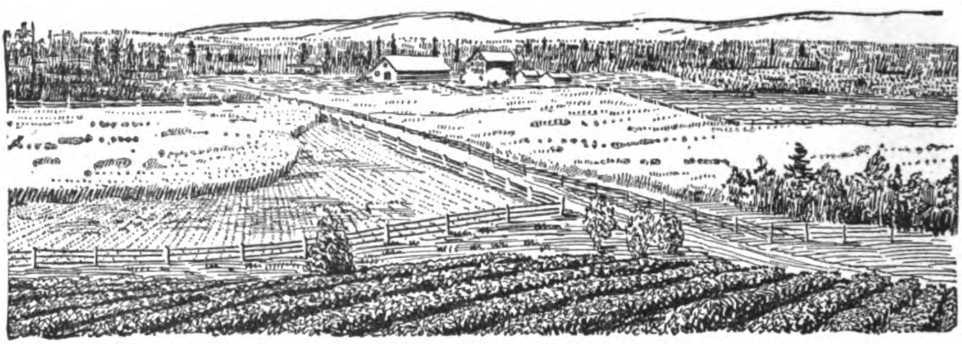


FIG. 217. The principles of successful crop management are neither local nor sectional but national—even universal. This practical farm scene is a view of an Alaskan countryside. Like the methods that produce its crops, it might just as well represent the Atlantic as the Pacific coast, or, for that matter, much of the country between.

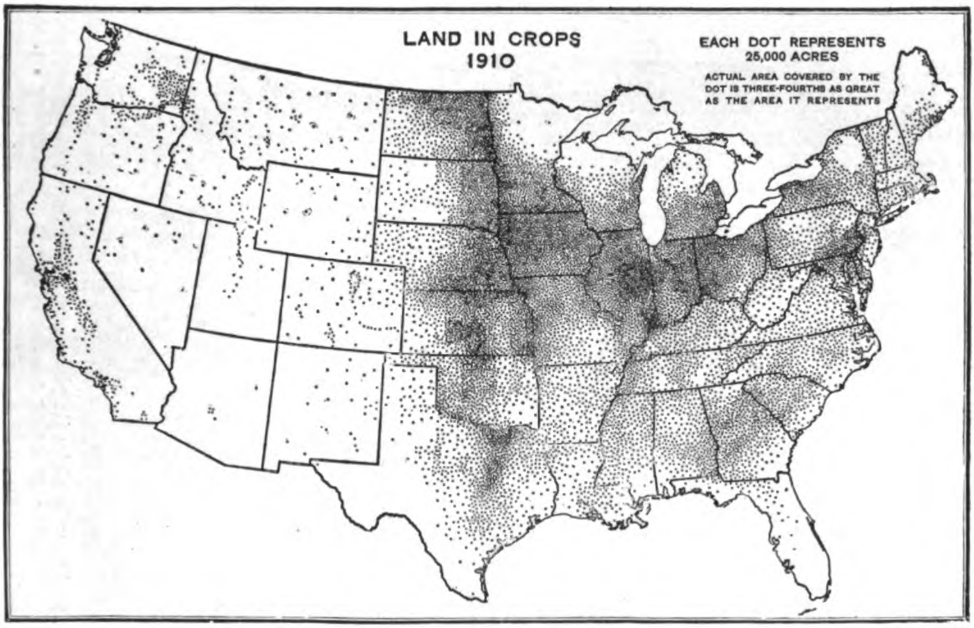
CHAPTER 26

How to Grow Field Crops

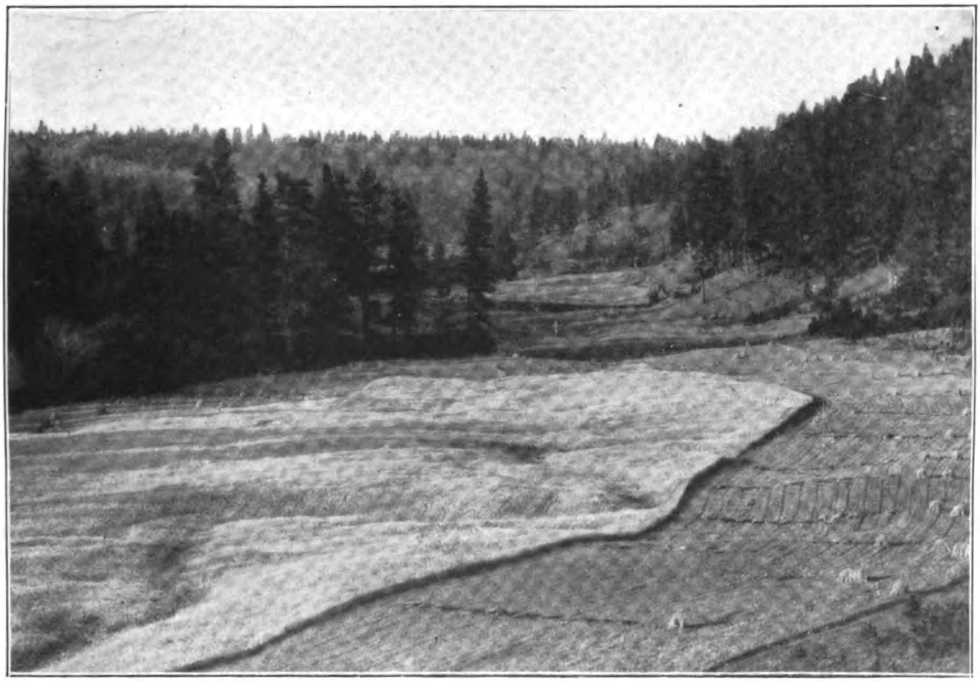
FIELD crops and their culture are the keystones of general farming. As treated in this chapter they include (1) the corn crops; (2) the small grains; (3) the forage crops, consisting of legumes and non-legumes; (4) root crops; and (5) a group of miscellaneous and unrelated, but important, crops grown mostly for cash sales.

In succeeding chapters are discussed fruit crops, vegetable crops (which include some discussed under Section E of this chapter but more intensively and on a smaller scale), forest products and the ornamental materials—flowers, shrubs, and shade trees—with which farm homes can be made attractive as well as profitable.

The authors of this chapter are essentially practical farmers, whose farm life and practical experience have supplied an invaluable background for their research and teaching activities. The best possible advisor in matters of farm practice is he who has done the things he talks or writes about, who has studied the reasons for his methods, and who has learned how to explain them to others. Professors Hutchinson, Hackleman, and Hughes, and Messrs. Fraser and Nelson, all fulfill each of these requirements.—EDITOR.



It is hard to realize that of the vast territory of the United States, less than half, as shown here, is in crops (1915 Yearbook, U. S. Dept. of Agr.)



But it is sometimes harder to realize that some land is far better left in grass or timber than subjected to the risks of cultivation

ONE OF THE FARMER'S LARGER PROBLEMS IS TO DECIDE WHAT LAND TO FARM AND WHAT TO LEAVE IN NATURE'S CARE

CORN FOR SILAGE AND FOR SEED.-- Had America never done anything else, it could justly claim its place among the foremost agricultural nations of the world as the source of maize—what we know as corn. This shows a bumper crop being cut for silage; the insets show typical prize-winning seed ears—a dent variety at the left, a flint variety at the right. (Large photograph by courtesy of The American Agricultural Chemical Company.)

A. THE CORN CROPS

By PROFESSOR C. B. HUTCHISON, *Department of Plant Breeding, New York State College of Agriculture, who was born and reared on a Missouri farm in the development of which he is still interested. As a student in the Missouri College of Agriculture, he took an active part in organizing the Corn Growers' Association of that state, of which later on, he was Secretary for 6 years. After graduating, he joined the instructing staff of the College becoming head of the Department of Farm Crops in* 1914. *In addition to his work in Missouri, Professor Hutchison has studied at Cornell and Harvard Universities working along plant-breeding lines—the same in which he is at present engaged.*—EDITOR.

THE corn crops include those plants of agricultural value derived from the Indian corn or maize species, called by botanists *Zea Mays*, and the common sorghum and Kafir series (*Andropogon Sorghum*). All of these plants are large, rank-growing, annuals, semi-tropical in nature and adapted to regions with fairly long, hot summers. Corn is above all an American crop and its production constitutes the greatest single industry of this nation. The annual production of the United States closely approaches 3 billion bushels and exceeds in value that of all the other grain crops combined.

Sorghum has been developed chiefly in the Eastern Hemisphere, particularly in southern Asia and Africa, and constitutes the chief food crop of those countries. It has but recently become an important crop in the United States where, except for its use in sirup and broom making, it is grown almost entirely as a stock and poultry feed. During the last 20 years, the culture of the grain types has spread very rapidly in southwestern United States where it has extended the corn-growing area into regions too dry for maize and has added considerably to the agricultural wealth of the country.

Maize, "Indian Corn" or "Corn"

The origin of corn, like that of most of our cultivated crops, is not fully known or easy to trace. It is closely related to and readily crosses with teosinte, a rank-growing, tropical grass of Mexico and southern United States. It is probable that the development of both these plants has been along similar lines.

In all probability corn was first cultivated in central Mexico. From there it spread into North and South America and at the time of the discovery of the new world was widely distributed throughout both continents. Columbus and other early explorers introduced it into several European countries, from which it has spread into many parts of the world; but only in the Western Hemisphere has it become an important crop.

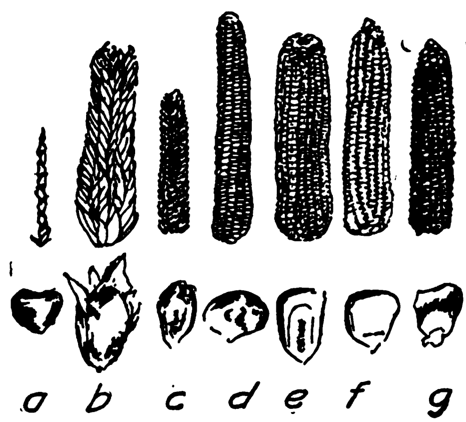


FIG. 218. Ears and kernels of the different members of the corn family: *a* teosinte; *b* pod corn; *c* pop corn; *d* flint corn; *e* dent corn; *f* soft corn; *g* sweet corn.

Types or Races

There are 6 principal types or races of corn, of which the grouping is based chiefly upon the character of the kernels. These are (1) pop corn; (2) flint corn; (3) dent corn; (4) flour or soft corn, (5) sweet corn, and (6) pod corn.

Pop corn (*Zea Mays everta*). Kernels small, very hard, and flinty with little or no soft starch in the endosperm or portion surrounding the germ (Fig. 230). When the kernel is

FIG. 219. Field of dent corn, the principal type grown in the United States. (This and Fig. 221 from Farmers' Bulletin 537).

heated, moisture within it explodes causing it to turn inside out and form a white, starchy mass. Used solely as a confection. Two types, *pearl*, with smooth, round kernels; *rice*, with pointed kernels. Ears small 2 to 6 inches long with 8 to 16 or more rows of kernels. Red, blue, bronze, black, yellow, white and variegated colors. Many varieties, but the white rice is the most popular. Grown commercially chiefly in Iowa and Nebraska.

Flint corn (*Zea Mays indurata*). Kernels rounded, very hard on the outside, with soft starch in the centre. Ears small in diameter 6 to 14 inches long, with 8 to 14 rows of kernels. All colors; many varieties. Grown chiefly at high elevations and northern latitudes in climates too cool for dent corn.

Dent corn (*Zea Mays indentata*). Horny starch grouped at sides of kernel. Soft starch in between and extending to the top; characteristic dent in end of kernels due to shrinking of this soft starch at maturity. Ears usually large, 6 to 12 inches in length, 6 to 8 inches in circumference, with 8 to 24 rows of kernels. In larger ears kernels flat-topped and distinctly wedge shaped. All colors; numerous varieties. The principal type cultivated in the United States.

Soft corn (*Zea Mays amylacea*). Kernels smooth, rounded like flint corn. Endosperm all soft starch. Ears 6 to 10 inches long, 8 to

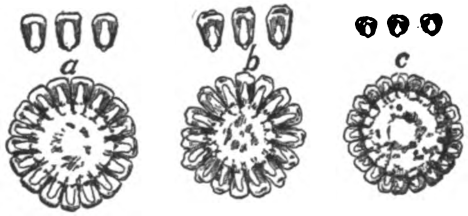


FIG. 220. Sections showing good and poor proportions of cob to kernel. *a* Medium cob, large, uniform, well packed kernels; *b* cob too small, kernels too long, thin and loosely arranged; *c* cob too large, kernels too shallow. (International Harvester Co.).

16 rowed. Chiefly red, blue, white and yellow colors. Several varieties. Grown commercially in southwestern United States, Mexico, and South America.

Sweet corn (*Zea Mays saccharata*). Horny, wrinkled kernels with remarkably high sugar content. Grown chiefly as a vegetable to be eaten fresh, dried or canned. Two types: (a) 8 to 12 regular rows, broad to medium kernels; (b) numerous rows very irregular, narrow kernels. Colors chiefly black and white. Several varieties.

Pod corn (*Zea Mays tunicata*). Flower glumes form a husk or pod enclosing each kernel (*b* Fig. 218). No economic importance; grown only as a curiosity. No varieties.

The Parts of the Corn Plant

Roots. When a kernel of corn germinates several temporary roots are sent out which enable the young plantlet quickly to become established in the soil. The first permanent roots appear soon after the stem has pushed

FIG. 221. Field of flint corn showing type of plant adapted to the cooler parts of the corn regions. Compare with Fig. 219.

into the air, always developing at joints or nodes about an inch below the surface of the soil regardless of the depth at which the kernel has been planted.

These permanent roots grow outward and downward, branching and rebranching until in a short time the top 18 inches of soil is well filled with them. In loose open soils the roots often penetrate to a distance of 4 or 5 feet. After the corn plants are 20 to 30 inches high, many of the roots extend across the rows 3 or 4 inches beneath the surface, and care must be taken not to injure or disturb them by too deep cultivation.

Brace roots develop from the first 2 or 3 nodes above the surface of the soil. Upon entering it they branch and do the work of ordinary feeding roots, but their primary purpose is to brace the plant against winds.

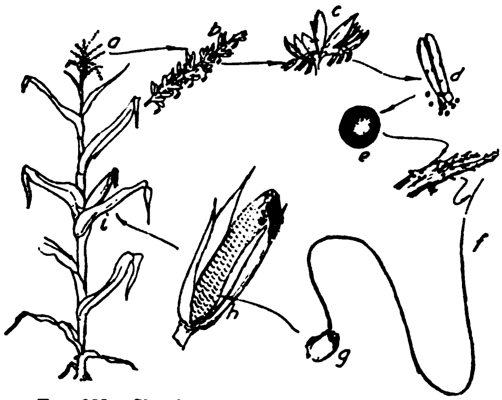


FIG. 222. Showing the steps in the development of the corn ear. The tassel (*a*) has on each branch (*b*) many staminate or male flowers (*c*). Each stamen (*d*) contains pollengrains (*e*) some of which when discharged light on the tip of a silk (*f*) which contains a tube leading to the ovary (*g*) which when fertilized becomes a kernel (*h*) on the ear (*i*)

The stem of the corn plant is divided by joints (*nodes*) into a number of sections (*internodes*). The number of nodes varies in different varieties or types but seems to be about the same in all members of a variety or strain. Small northern varieties have 10 to 12 nodes while the large, rank-growing sorts of the South have from 18 to 20. The height of the stem varies from 18 to 20 inches in some of the dwarf forms, to 18 to 20 feet in some of the large southern varieties. Unlike that of most grasses the stem is not hollow but filled with a soft pith.

Usually a plant has but one *culm* or stem, but occasionally one or more *tillers* or suckers will develop from buds at nodes near the soil surface. If the stand is crowded, the soil thin or the moisture supply deficient, these buds never grow, or the tillers drop off before they have made much growth. If conditions are more favorable the tillers may reach full height and produce more or less grain. Sweet, pop, and pod corn tiller more than the dent types, and some varieties tiller more freely than others. It does not pay to remove tillers, in fact, their removal may sometimes actually decrease the yield of both grain and stover.

The leaves are the part of the plant in which the raw material taken in by the roots and the leaves themselves is converted into food and plant tissue. The number of leaves varies with the number of nodes. Heavily leaved varieties are preferred for silage. In times of drought the leaves roll inward reducing the area exposed to the sun and wind and the amount of moisture lost from them.

The flowers. The male and female reproductive organs (flowers) are separate in the corn plant. The tassel bears the male (*staminate*), flowers in which the pollen is produced. The female (*pistillate*) flowers are borne on a fleshy side stem which grows out about half way up the main stem. The pistil of each flower extends beyond the husks and is called the silk. A pollen grain falling on the end of a "silk" sends out a tube which finds its way down through the silk to the ovary at the base. Two male reproductive cells from the pollen grain pass down this tube and enter the ovary where one unites with the egg cell to form the *embryo*, and the other with the vital cell of the endosperm to form the latter. The flowers at the centre of the cob are ready for fertilization first, the zone of fertilization gradually passing to both ends. Should a silk fail to receive a pollen grain, or be injured before fertilization has taken place, the kernel at its base fails to develop. This frequently happens to flowers at the outer end of the cob, leaving the tip slightly exposed.

The pollen of any plant usually ripens and is shed 2 or 3 days before the silks appear. This tends to prevent their fertilization by pollen from the same plant. It is estimated that a single plant produces about 20 million pollen grains while the number of kernels on an average ear is about 500 or 600. The chances for the fertilization of each egg cell are therefore very great. Pollen is very light and is carried by the wind sometimes for a fourth of a mile or even farther. It is, therefore, difficult to keep a variety pure when neighboring farmers grow different kinds of corn.

Climate and Soil Required

Climate. The ideal corn climate is one of a summer without frost, 4½ to 7 months long, the middle portion hot both day and night, with abundant sunshine and sufficient rainfall, evenly distributed throughout the growing season, to meet the demands of a rapidly growing and luxuriant crop.

There is a very close relation between the rainfall of July and August and the yield of corn in the main Corn Belt. Most good corn soils in that section contain enough moisture supplied by winter and spring rains to support the crop until late June or early July without much rainfall. Thereafter the crop must depend upon the season's rainfall; if it is not forthcoming the yield is materially lessened.

FIG. 223. Corn plants vary widely as to the height at which they bear ears.

Soils and fertilizers. A crop which yields as much grain and stover as does corn is

FIG. 224. On muck soil corn yielded at the rate of 12 bushels per acre (*left*). The addition of 200 pounds of muriate of potash per acre resulted in a yield of 58 bushels per acre (*right*).

clearly a hard one on the soil; it requires high fertility for its best development. Rich, fertile soils such as are found in well-drained bottom lands and the best prairie sections of the Mississippi Valley make up the nation's best corn lands. Corn is, of course, widely grown elsewhere but always with greater need of attention in modifying the soil, than in naturally favorable sections.

Many farms in the Corn Belt, however, have been planted to corn for so long that their fertility has been considerably reduced. The problem of maintaining the fertility of the soil so that corn production will continue profitable in those sections is becoming more important every year. Corn, like most other farm crops, does not produce large enough gross returns to justify an extensive use of fertilizers. The grower must, therefore, depend largely upon the soil and upon farm manures for this crop's food. A good cropping system is the first essential toward maintaining good yields, but this in time must be supplemented by the use of manures and fertilizers if the soil is to be kept in the highest state of fertility.

The effect of the cropping system and the use of fertilizers on the yield of corn is well shown by the following average yield per acre obtained in two sets of experiments on land handled in different ways (Illinois Bulletin 125).

CROP YEARS	CROPPING SYSTEM	YIELD IN BUSHELS	
		1st Test	2nd Test
1905-6-7	Corn every year	85	27
1903-5-7	Corn and oats alternated	62	46
1901-4-7	Corn, oats, clover	66	58

The original productive capacity of this land was about 70 bushels of corn to the acre. Thus, while a good rotation tends to maintain productiveness, it cannot entirely do so if all of the crops are removed from the land. Of course it has other beneficial effects. (See Chapter 31).

In another experiment at the Illinois Station, two series of plots were cropped to a corn, oats, clover rotation. On one set the corn and oats grain and the clover seed was removed, the corn stover and oat and clover straw being returned to the land, in addition to a catch crop of cowpeas grown in the corn and turned under. On the other series the crops were all removed and manure applied in proportion to the crop yields, thus approximating a system of livestock farming where the crops are all fed and the manure returned to the land. Mineral fertilizers were applied in each case with the following results:

CROP YEARS	FERTILIZER TREATMENT	YIELD NO MANURE BUSHELS	YIELD MANURE BUSHELS
1905-6-7	None	69	81
1905-6-7	Lime	72	85
1905-6-7	Lime, phosphorus . . .	90	93
1905-6-7	Lime, phosphorus potassium. . .	94	96

Thus, where manure is used with a rotation the yield of corn has not only been maintained but even increased, whereas, a rotation alone, even where only the grain has been removed, is not sufficient to keep up the fertility of the soil. The use of fertilizers with both systems has materially increased the yield of corn. Fertilizers alone, however, should never be depended upon to maintain or increase corn yields even in those sections of the country where they are used considerably with this crop.

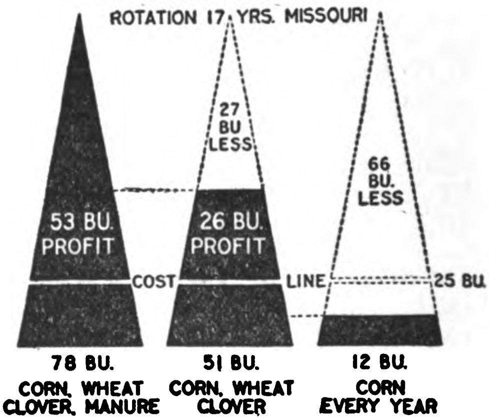


FIG. 225. The effect on corn yield of (*a*) rotation, keeping of livestock and use of manure; (*b*) rotation including plowing under of legumes; and (*c*) continuous cropping to corn. (International Harvester Co.)

Growing the Crop

Selecting a variety. There are probably a thousand named varieties of corn. Most of these have been developed by farmers in different sections of the country through many years of careful selection. Thus various sections of the corn-growing region have come to possess certain fairly distinct types. In the Gulf States "prolific" varieties of dent corn, which have a tendency to produce two or more ears on a stalk, are grown; north of the Ohio River, large, one-eared dent varieties are grown; while in between is a section in which both prolific and one-eared sorts occur. Flint corn is grown in the North, particularly in New England, and at high altitudes in mountainous regions elsewhere.

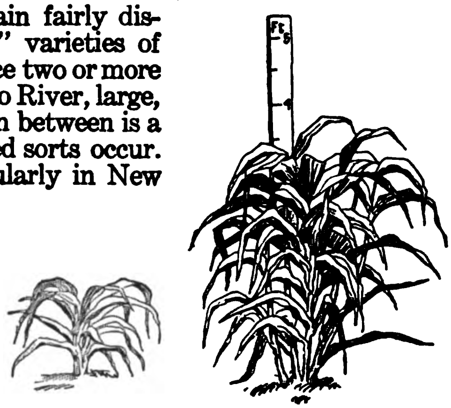


FIG. 226. These plants grew 90 feet apart on the same kind of soil. The same crop rotation was practised and the same fertilizer was added on each plot. The only difference was that the soil that grew the smaller plant was acid; the other was sweetened by the presence, near the surface, of a bed of limestone (Pa. Bulletin 131)

Some of the best known prolific varieties are Mosby's Prolific, Cocke's Prolific, Marlboro Prolific and Blount's Prolific.

Among the most important large white dent varieties of the Middle West are Boone County White, Johnson County White, Silvermine and St. Charles County White. The most important yellow dent varieties are Leaming, Reid's Yellow Dent, Riley's Favorite and Legal Tender.

Among the early dent varieties adapted for the north are Pride of the North, Wisconsin No. 7, Minnesota No. 13, and Silver King.

The best known flint varieties are King Phillip, Gold Nugget, Smut Nose, Sanford White, Eight-Rowed White, Twelve-Rowed Yellow and Longfellow.

One should select the variety best suited for his conditions and then save his own seed each year or purchase it from some reliable grower in his own locality who makes a business of producing good seed corn. Seed brought from a distance may be expected to yield less by 5 to 10 bushels per acre than equally good seed of the same variety that has been grown in the locality for 3 or 4 years.

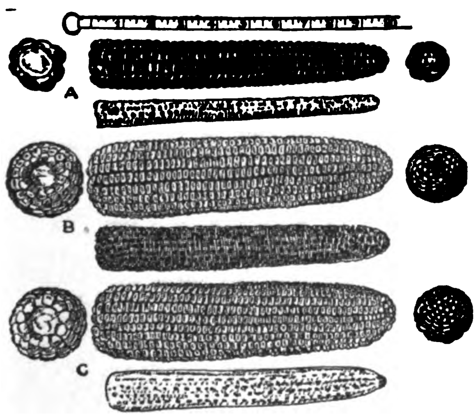


FIG. 227. Typical ears of three standard varieties, showing in each case the whole ear, the butt, the tip and the cob. A Canada Cap Flint; B Reid's Yellow Dent; C Boone County White Dent. (Amer. Agr. Chemical Co.)

Improving a variety. A high-yielding ear of corn cannot, within certain limits, be selected by any visible characters any more than a high-producing dairy cow. The best basis on which to select either is the performance of its ancestors and itself. The highest-yielding ear of a group may be located by planting kernels from each of them in separate rows under uniform conditions and weighing the product of each ear separately. Then by carefully saving seed from the best plants of the highest-yielding, earliest-maturing or otherwise most desirable rows, and planting them in an isolated plot, improved strains may be obtained. Since the male parentage of the crop of any row cannot be controlled, and since

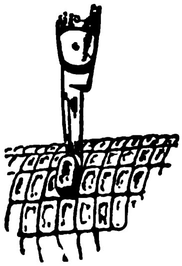


Fig. 228. The right way to remove a kernel for testing.

ears from the best rows in such a test may have received pollen from inferior plants, a shorter cut to the desired end is to save a part of each ear tested. Then, when the best ears have been found by trial, mix this remaining seed and plant it all in an isolated plot the following year. Such simple breeding methods have been found to increase the yield from 10 to 15 per cent.

Selection and Care of Seed Corn

Seed corn should be gathered in the fall after it is well matured and before heavy frosts, and stored in a dry, well-ventilated place where it will dry out quickly. Fairly low temperatures are not likely to injure seed if dry, but light freezes while the grain is full of moisture will often kill or weaken the germ.

Seed corn should be selected in the field where the character of the plant, its maturity, and its surroundings may be observed. If selected from the crib just before planting, not only is the vitality apt to be low but ears may be selected which were borne on weak stalks or on plants that grew on a specially rich spot or where the stand was thin. The best seed is that produced by good plants, grown under normal conditions, as respects soil and stand, and which matures well; these facts can be determined only in the field.

Germination test. Even if care in drying and storing is taken, it is always a wise precaution to make a germination test of seed corn before planting. A simple and partial test may be made by removing 5 or 6 kernels from each of 50 or 60 ears taken at random from the entire lot of seed and starting them in a shallow box of sand or other germinator. If this preliminary test shows the corn to be of strong vitality, it can safely be planted; but if less than 90 to 95 per cent of the kernels germinate, an individual ear test should be made. Here is one of several convenient methods for making such an ear test:

Fill a shallow box 2½ inches deep and 20 inches square with sand. Divide the surface into 2-inch squares by running strings across both ways. Number the rows of squares along one side 1, 2, 3, 4, up to 10, and along the other, A, B, C, D, up to J. Select 100 ears for test and number each to correspond with a square in the germination box. Place 10 kernels taken from various parts of each ear in the square corresponding to its number. Cover with sand, moisten thoroughly, cover with a cloth or sack and set away in a warm place for 4 or 5 days, sprinkling frequently to keep the sand from drying out. Save for seed only those ears from which all 10 kernels have produced strong healthy sprouts.

A B C

Fig. 229. How seed curing affects the stand. The seed for each of these pairs of rows was cured differently: on the south side of a barn A; in a tool house B; in a furnace room C. (Wis. Circular 58).

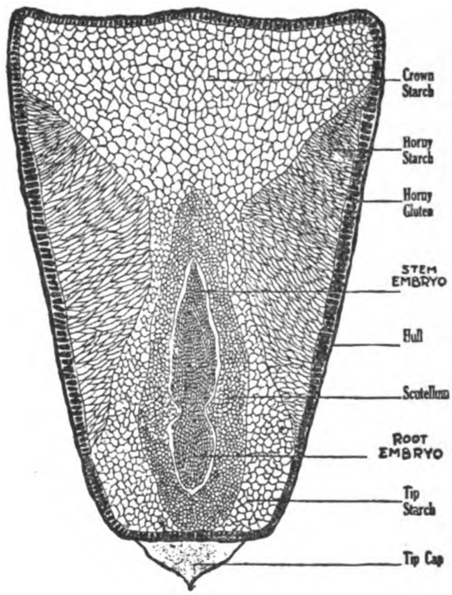


Fig. 230. The parts of a corn kernel (International Harvester Co.)

Preparing the Land for Planting

When to plow. The best preparation of land for corn depends largely upon the previous crop and the way in which the land has been handled in recent years. It is usually best to plow sod land in the fall to increase the decay of the organic matter and destroy insects such as wire worms and cut worms that might attack the corn in the spring. Level stubble land may also be plowed in the fall to good advantage but very rolling land usually washes more when fall plowed than if left until spring.

A good way to distribute labor is to plow at least part of the land in the fall and have this much work out of the way of the spring rush. Spring plowing should be done as early as possible to conserve moisture, set free plant food and afford sufficient time to prepare a good seedbed.

How deep to plow. In general, corn land should be plowed fairly deep—7 or 8 inches, although the proper depth will depend largely upon the character of the soil. Heavy clay soils and those badly worn by long continued cropping usually require deeper plowing than sandy soils or those in better condition.

Plowing is the most expensive tillage operation in corn production; also it is the most important. Unless the soil is well pulverized and all trash or manure is completely covered, unprepared spots are left in the field rendering the highest yields impossible. If manure or other organic matter is to be turned under a thorough disking before plowing works it into the soil and saves labor in later operations. The rest of the work should be sufficient to leave a well-compacted seedbed below with a layer of loose, well-pulverized soil on top.

Listing. West of the Missouri River and in the South much corn land is not plowed at all but prepared for planting by listing. A lister is in effect a double moldboard plow which opens up a furrow by throwing the soil out on both sides. The furrows are made where the rows are to run and the soil left unstirred between them. The corn is then drilled in the furrows with a corn drill; or the listing and planting may be done at once with a combined lister and drill. This is a quick, inexpensive method of planting but one adapted only to deep, rich, loose, well drained soils. The heavy clay soils of much of the East are not suited to this practice. In the West listed corn withstands the drought better than that planted on the surface and the plants are not so easily blown down.

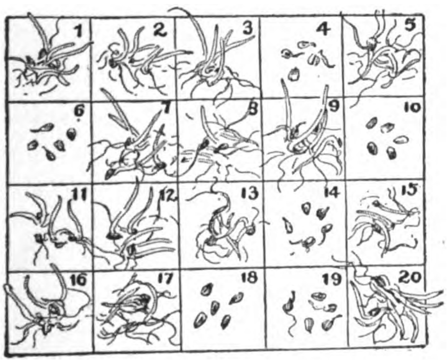


FIG. 231. Germination test box showing how the desirable ears and strains are distinguished. Note difference between squares 1, 2, 3, 7 and 20, and 4, 6, 10, 14 and 18. (International Harvester Co.)

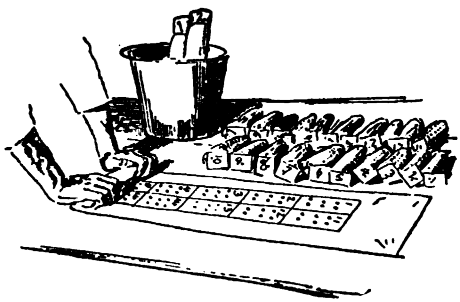


FIG. 232. Testing corn with a rag-doll tester, which is a strip of cloth 9 by 60 inches in size. Twenty squares are drawn on it; in each are placed 6 kernels from ears numbered to correspond; then the doll is rolled up, and stood in water for a few days until the kernels sprout. (International Harvester Co.)

Planting. Small corn fields are generally planted by hand with 1- or 2-row drills. Check-row planters are used on level land and in large fields; this is the principal method in the Corn Belt. Drilling is usually confined to new lands, relatively free of weeds, or to level, poorly-drained lands where one-way cultivation promotes surface drainage.

The advantage of check-row planting is that it permits of cultivating the corn both ways and controlling weeds more easily. On sod land, or where weeds do not bother, drilled corn sometimes yields a little better than that planted in hills since the plants are not so crowded.

Furrow openers consisting of 2 disks attached to the runners of an ordinary planter, are sometimes used to open up furrows in ground that has been plowed and thoroughly prepared. The chief disadvantage here seems to be that weed seeds that have been buried by plowing are thus exposed and given another chance to compete with the corn planted at the bottom of the furrow with them. Furrow openers are used chiefly in the Middle West on deep, level, well-drained soils where water will not stand long in the furrows.

When to plant. Corn planting begins in the Gulf States about March, and ends in Minnesota and North Dakota about June 15. The table from the 1910 Yearbook of the U. S. Department of Agriculture shows the average time of planting corn in different parts of the United States. In any region midseason planting is usually safer than either extremely early or late planting. In the central and southern states early-maturing varieties are sometimes planted much later than the above dates on overflow lands or as a catch crop following the removal of some early crop.

How much seed to plant. Field corn is usually planted at the rate of 4 to 6 quarts to an acre. In the Corn Belt a bushel is considered enough for 6 or 8 acres depending upon the size of the

REGION	PLANTING PERIOD			
	Beginning	General	Ending	Days
Gulf States, Georgia to Texas......	March 15	April 5	May 15	60
Central States, Virginia to Kansas...	April 15	May 1	May 25	40
Northern States, N. Y. to N. D..	May 10	May 20	June 1	20

kernels. For silage from 6 to 8 quarts are used per acre. These figures naturally vary with the distances between hills and rows, and these in turn depend upon the region, the season and the soil. In the South, corn is planted in rows 4 or 5 feet apart with about 2 kernels in a hill; in the central states the rows are usually 3 feet 8 inches apart with 2 or 3 kernels to a hill; while in the North the rows are usually 3 feet 6 inches apart and 3 or 4 kernels are planted in a hill. This difference is due chiefly to the larger size attained by the plants in the South. On poor soils and in dry seasons thin planting gives more and better grain than thick planting. Stover yields usually increase directly with the rate of planting. The effect of rate of planting upon yield of grain and stover is illustrated by the following table from Bulletin 212 of the Ohio Experiment Station giving averages for the years 1904-6-7 and 8.

FIG. 233. Stringing ears for curing. Insert shows how to start.

If a stand is too thin the individual plants often show an increased development of tillers, a larger ear, and a reduction of the per cent of barren stalks. On the other hand if the stand is thicker than normal the ears are smaller and the per cents of nubbins and barren stalks are increased.

How deep to plant. Corn should be planted only deep enough to insure prompt germination. On Eastern clay soils, 1 inch deep is usually sufficient; in the West on drier soils and especially in dry seasons deeper planting is necessary. However, corn is seldom planted more than 1½ to 2 inches deep.

Cultivation

The chief reasons for cultivating corn are (1) to destroy weeds; (2) to conserve moisture; (3) to distribute air through the soil; (4) to increase bacterial action in supplying nitrogen, and (5) to aid in making mineral plant food available. The first of these is by far the most important. If the seedbed has been well prepared only such cultivation as will kill the weeds is generally needed after the seed is planted.

In dry regions, or in dry seasons while the plants are small, and wherever conditions more nearly approach that of a fallow field, early cultivation forming a mulch may prevent the loss of considerable moisture by evaporation.

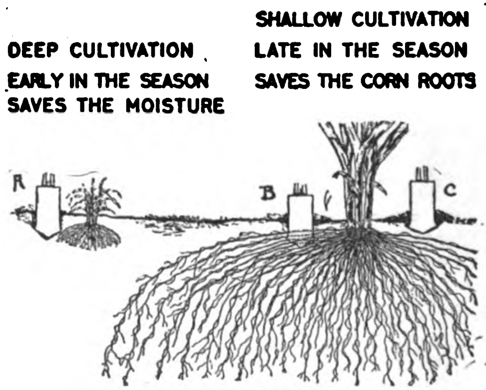


FIG. 234. Early cultivations may and often should be deep (A), but later ones must be shallow (C), or roots will be injured (B). (International Harvester Co.).

NUMBER OF PLANTS		AVERAGE WEIGHT OF EAR	PERCENTAGE		YIELD PER ACRE OF	
Per Hill	Per Acre		Of Nubbins	Barren Stalks	SHELLED CORN	STOVER
1	3,555	.680 lb.	10.3	2.2	31.47 bu.	2,484 lbs.
2	7,110	.621	15.8	2.4	50.26	3,390
3	10,665	.545	19.5	4.0	59.28	3,994
4	14,220	.463	28.4	7.4	61.95	4,495
5	17,775	.400	39.8	11.8	60.29	4,969

It is not likely that much moisture is saved by this means after the corn is 3 or 4 feet high.

On heavy clay soils that tend to "bake," cultivation may often increase the supply of available moisture by keeping a loose, open layer of soil on top to absorb rainwater and allow it to soak into the soil for the use of the crop instead of letting it run off the surface. On poorly-drained, compact soils frequent, fairly deep stirring often does much along the lines listed as (3), (4) and (5) above.

The relation of weeds and moisture to corn cultivation is well illustrated by data taken from Bulletin 181 of the Illinois Experiment Station, giving average yields in bushels per acre obtained on two plots.

Thus weeds and not moisture represent the important factor in corn cultivation; and the best practices are therefore those which rid a field of weeds with the least injury to the corn plants.

Deep and shallow cultivation. No fact concerning corn production is better established than that under ordinary conditions shallow cultivation gives best results. In general, cultivation may be deeper and closer to the plants early in the season before the roots have extended far. Late cultivation should be shallow and, where drainage is good, should leave the soil as level as possible.

TREATMENT	AVERAGE YIELD	
	6 Year	8 Year
Not plowed or cultivated; weeds kept down by scraping with hoe	33.0	31.4
Plowed, seedbed prepared, no cultivation; weeds kept down with hoe	47.3	45.9
Plowed, seedbed prepared, weeds allowed to grow	5.3	7.3
Plowed, seedbed prepared, weeds allowed to grow, irrigated	11.7*	—
Plowed, seedbed prepared, cultivated shallow 3 times	42.9	39.2
Plowed, seedbed prepared, cultivated shallow 3 times, irrigated	52.3	47.7
Plowed, seedbed prepared, cultivated shallow 3 times, irrigated, fertilized	76.2	—

*Four-year average.

Harvesting and Using the Crop

How to harvest. Corn is harvested in the following ways: 1. The whole plant is cut by hand or machines for fodder or silage. 2. The ears only are harvested leaving the stalks standing in the field. 3. The tops are cut off just above the ears and cured for fodder. Later the ears are harvested. 4. The leaves are stripped when still green and cured for fodder and the ears are gathered later.

By far the greatest part of the corn crop of the United States is harvested by the first two methods. The others are practised to some extent on small farms in New England and the South.

Harvesting the whole plant. Formerly where the whole plant was harvested it was cut by hand and shocked in the field. Later the ears were removed by hand and the stover fed. Considerable corn is still handled in this way but in recent years corn binders have come into general use, especially on the larger farms. Corn is usually cut when the ears are well glazed or dented and when the husks and lower leaves have ripened.

FIG. 235. Types of husking peg (Farmers' Bulletin 313)

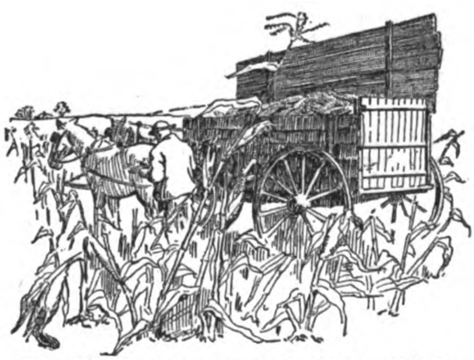


FIG. 236. Wagon with extra sideboard used in harvesting corn from the standing stalks. (Farmers' Bulletin 313).

Shredding. Frequently the fodder when well cured and dry is run through a shredder which removes the ears and shreds the stems and leaves which are then stored in barns or sheds and fed as hay.

FIG. 237. Too much corn is allowed to go to waste. Farmers should learn how to use the entire plant

Silage. Much corn is now put in the silo and fed on the farm. A silo is practically a huge can in which finely-cut corn or other green material is tightly packed and is thereby preserved. Corn is ready to cut for silage when the kernels are all glazed. Usually the best grain variety for any region planted a little thicker than usual is best for silage.

Most of the crop in the main Corn Belt is still harvested by hand leaving the stalks standing in the field (machines have been built for picking corn but they are clumsy affairs and have never come into general use). The stalks are then pastured off with cattle, horses and sheep. This is a much more wasteful practice than ensiloing since fully 40 per cent of the total food value of the plant is in the stems and leaves, and but little of this is recovered.

Yields. These naturally vary greatly with the location, season, variety, quality of seed, type of soil and kind of farmer. The average yield per acre for the United States is close to 26 bushels, but no farmer should ordinarily be satisfied with such a performance. If he makes 50 or 75 bushels he is doing very well, while a yield of 100 bushels or more indicates highly favorable conditions and good management. Small areas have produced at the rate of over 200 bushels but this is hardly possible commercially under existing conditions. Ten tons of silage corn is a good average yield.

How corn is used. By far the greatest part of the corn crop of the United States is fed on the farms on which it is grown and is marketed in the form of beef, pork or mutton. In certain states, particularly Illinois, Nebraska, Iowa and Indiana, considerable grain is marketed, but most of this, too, finds its way back to the feed lot. Only about 2 per cent of the total crop of the United States normally is exported and occasionally some is imported.

Besides its extensive use in animal feeding, corn and its products are used in a variety of ways. The husks are made into mattresses, the pith of the stalks into packing, the cobs into pipes and the grain into breakfast foods, alcohol and other food and commercial products. The most important corn products are: *Corn meal*, used chiefly for bread and mush; *corn grits*, or coarsely ground meal, used as a cereal; *hominy*, whole, cracked, or flaked, used as a cereal; *glucose* or *corn syrup*, made by changing the starch to sugar by treating it with a solution of hydrochloric acid; *corn starch*, extracted, by washing, from the corn flour; *gluten feed*, left after the extraction of glucose and starch; and *germ meal*, a by-product of glucose, hominy and starch factories consisting largely of the germs of the kernels. Gluten feed and germ meal are rich in protein and are used chiefly for stock food. *Oil* is pressed from the germs and is used as a salad oil, in paints and as a substitute for vulcanized rubber. *Corn oil cake*, or the material left after the oil is pressed out is another protein stock feed. *Distillery products*, left after alcoholic beverages have been distilled from the crushed grain, are used in various forms as stock feed.

Markets

The farmer's surplus corn is usually sold to a local elevator which may be an independent concern, a coöperative enterprise in which the farmer himself is financially interested, or one of a series of line elevators along some railroad controlled by an organization with headquarters in the central or terminal market. From the local elevator the corn either goes back to a feeder in the community or is shipped to the terminal or primary market such as Chicago, St. Louis, Kansas City, and other points. There it is purchased in large quantities by millers, exporters or others.

Market grades. At the terminal market, corn is officially inspected, graded and sold as a definite grade of white, yellow or mixed corn or as sample grade. The market grades of white corn as adopted by the United States Government are as follows (those of yellow and mixed corn being similar):

"*Number one, white.* Shall be white corn; shall be sweet; shall contain not more than 14 per centum of moisture, not more than 2 per centum of foreign material and cracked corn, and not more than 2 per centum of damaged corn; shall not contain heat-damaged and mahogany kernels; and shall weigh not less than 55 pounds per Winchester bushel.

"*Number two, white.* Shall be white corn which does not come within the requirements of grade Number one, white; shall be sweet; shall contain not more than 15½ per centum of moisture, not more than 3 per centum of

FIG. 238. What is the use of harvesting corn at all, if it is to be kept this way? A good crop deserves good care.

foreign material and cracked corn, and not more than 4 per centum of damaged corn; shall not contain heat-damaged and mahogany kernels; and shall weigh not less than 53 pounds per Winchester bushel.

"*Number three, white.* Shall be white corn which does not come within the requirements of grade Number one, white, and grade Number two, white; shall be sweet; shall contain not more than 17½ per centum of moisture, not more than 4 per centum of foreign material and cracked corn, and not more than 6 per centum of damaged corn; and shall not contain heat-damaged and mahogany kernels.

"*Number four, white.* Shall be white corn which does not come within the requirements of grade Number one, white, grade Number two, white, and grade Number three, white; shall be sweet; shall contain not more than 19½ per centum of moisture, not more than 5 per centum of foreign material and cracked corn, and not more than 8 per centum of damaged corn, which may include not more than one half of one per centum of heat-damaged and mahogany kernels.

"*Number five, white.* Shall be white corn which does not come within the requirements of grade Number one, white, grade Number two, white, grade Number three, white, and grade Number four, white; shall be sweet; and shall contain not more than 21½ per centum of moisture, not more than 6 per centum of foreign material and cracked corn, and not more than 10 per centum of damaged corn which may include not more than 1 per centum of heat-damaged and mahogany kernels.

"*Number six, white.* Shall be white corn which does not come within the requirements of grade Number one, white, grade Number two, white, grade Number three, white, grade Number four, white, and grade Number five, white; shall contain not more than 23 per centum of moisture, not more than 7 per centum of foreign material and cracked corn,

FIG. 239. This is about the simplest sort of crib in which corn can be kept in good condition where rain and snow may be expected.

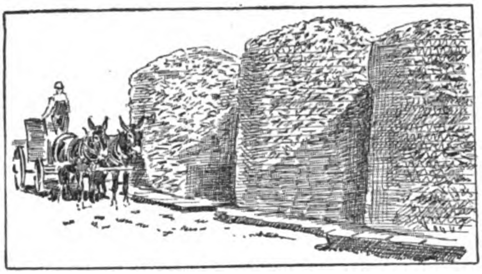


FIG. 240. In dry regions, a surplus can temporarily be stored in cribs made of woven wire fencing

and not more than 15 per centum of damaged corn which may include not more than 3 per centum of heat-damaged and mahogany kernels; may be musty or sour; and may include corn that is immature and badly blistered.

"Sample grade shall be corn which does not come within the requirements of the grades for white corn, the grades for yellow corn, and the grades for mixed corn, including corn that is hot, fire-burned, infested with live weevils, or otherwise of distinctly low quality."

Enemies

The only disease of any importance attacking corn is the corn smut and even it does relatively little damage; there is no effective means of control. The corn-root worm and the corn-root louse attack only corn and are easily controlled by crop rotation. Cut worms, wire worms and grub worms are apt to do much damage to corn, especially on sod land; early fall plowing will disturb their winter quarters and destroy many worms. Chinch bugs, army worms and grasshoppers often attack the crop and do serious damage. The first two which are most destructive in dry seasons, may be kept out of a field by a dust or oil barrier. The corn weevil does much damage to stored grain, especially in the Southern states, and is probably the most difficult to control of all insects attacking corn. Varieties with tight fitting husks, completely covering the ear, if harvested and stored in the husk are usually attacked less than those with loose open husks or those husked before being stored. An effective but rather expensive method of control is to store the grain in tight bins and treat it with carbon bisulphide or heat (see Chapter 34).

Value and Production Cost

In the leading corn-growing states corn competes chiefly with wheat, oats, barley, rye, and hay. Considering the 10 leading corn states as a whole during the 10 years from 1907 to 1916, corn has given larger gross acre returns than any of these crops as the following table compiled from the 1916 Yearbook of the U. S. Department of Agriculture shows:

STATE	AVERAGE VALUE PER ACRE FOR 10 YEARS OF					
	Corn	Oats	Wheat	Barley	Rye	Hay
Illinois	$18.53	$13.24	$15.50	$19.53	$13.60	$15.28
Iowa	17.44	11.80	16.74	16.34	13.43	12.84
Missouri	15.84	10.20	13.36	15.67	11.84	11.92
Indiana	19.60	11.84	15.45	16.32	12.01	15.55
Kansas	10.61	10.41	12.78	9.22	11.31	10.75
Nebraska	12.34	9.62	15.84	10.80	10.90	11.32
Ohio	22.42	13.65	16.69	17.66	13.28	17.02
Averages	16.68	11.53	15.19	15.07	12.33	13.52

In Kansas and Nebraska wheat has given larger gross returns during this period than has corn. The same is true of barley in Illinois and by a slight margin of rye and hay in Kansas. Outside the Corn Belt these and other crops are frequently much more profitable than corn.

The production of corn entails relatively little risk. It is adapted to an extensive system of farming on comparatively cheap lands—conditions under which the other ordinary farm crops are also most profitably grown. On high-priced lands, near convenient markets even within the Corn Belt, truck and fruit crops are frequently more profitable than corn although they require more care and involve greater risk.

The cost of production of corn varies in different sections of the United States depending upon the value of the land, its productive capacity, the cost of labor and the use of labor-saving machinery. In general, corn is grown at a lower cost in the Middle West where the natural fertility of the soil is high, where little fertilizer is needed and where large, level fields permit of the use of labor-saving machinery. The cost of production in the Corn Belt has increased with the increased land values and cost of labor and machinery during the last 50 years from $6 to $8 an acre and 15 to 20 cents a bushel, to $14 to $16 an acre and 35 to 45 cents a bushel at the present time.

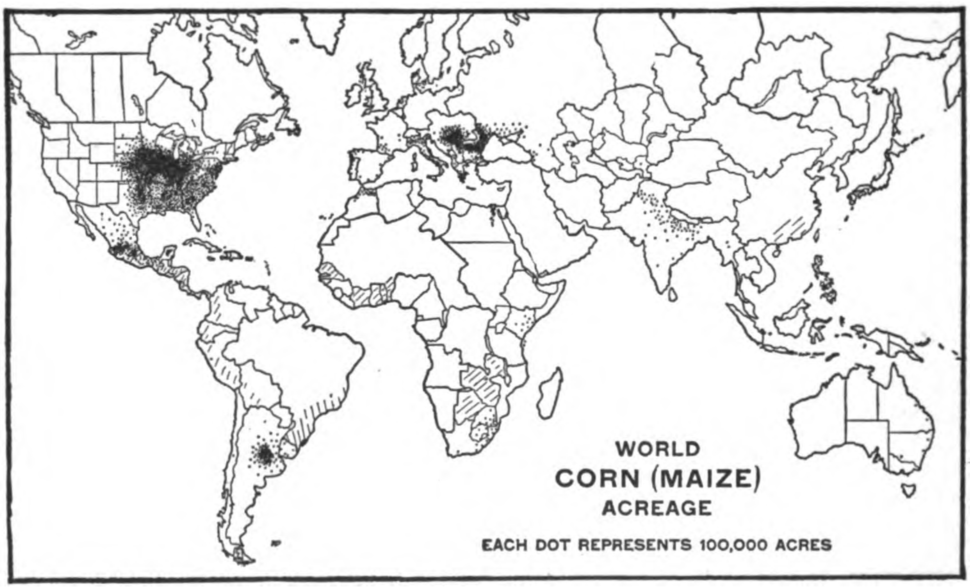


Fig. 241. This map shows plainly that corn is a Temperate Zone crop; the United States produces about three fourths of the world's supply. (1916 Yearbook, U. S. Dept. of Agr.)

Production, Distribution and World's Trade

The distribution of the world's crop of corn is shown in Fig. 241 and by the following average yields for the years between 1906 and 1910:

CONTINENT	TOTAL PRODUCTION BUSHELS	PER CENT OF WORLD'S CROP
North America	2,899,154,000	78.0
Europe	561,586,000	15.1
South America..	157,890,000	4.3
Africa..........	86,605,000	2.3
Australia	10,118,000	.3
Total........	3,715,353,000	100

Fig. 242. A field of Kafir in the arid Southwest

Corn-producing countries. More than 94 per cent of the crop of North America and three fourths of the total world's crop of corn is produced in the United States. Other important corn-producing countries are Hungary, Italy, Argentina, Mexico, Rumania, and Russia. Argentina leads the world in total amount of corn exported, the United States ranking second. Two other important exporting countries are Rumania and Russia. The principal corn-importing countries are normally the United Kingdom, Germany, Netherlands, Belgium, France, and Denmark.

Production in the United States. The 10 leading corn states according to figures for 1906 to 1910 are given in the accompanying table. Kansas, Nebraska, Iowa, Missouri, Illinois, Indiana, and Ohio constitute the Corn Belt. In no other part of the world is found such a large area in which the soil and climate are so well suited for the production of this crop.

STATE	ACREAGE	AV. ACRE YIELD BUSHELS	TOTAL PRODUCTION BUSHELS	PER CENT SHIPPED OUT OF COUNTY IN WHICH GROWN	TOTAL SURPLUS BUSHELS
Illinois...	9,777,000	36.4	355,908,000	41	145,922,000
Iowa.....	9,275,000	34.8	323,292,000	20	64,658,000
Missouri .	7,401,000	30.0	222,422,000	12	26,690,000
Nebraska.	7,422,000	27.1	201,315,000	38	76,499,000
Indiana ..	4,717,000	37.0	174,981,000	30	52,494,000
Kansas...	7,586,000	21.9	166,224,000	21	34,907,000
Texas....	6,824,000	21.3	145,764,000	8	11,661,000
Ohio.....	3,630,000	38.4	139,603,000	23	32,108,000
Oklahoma	5,053,000	19.2	97,456,000	22	21,440,000
Kentucky	3,359,000	27.8	93,634,000	10	9,363,000

The Sorghums

The botanical origin of the cultivated sorghums is but little, if any, better known than that of maize. Some students claim that they originated in Africa, while others contend that they had an independent origin in India as well. Undoubtedly the group was among the very first plants to be domesticated. Their culture began in prehistoric times and spread at an early date throughout Africa and the southern half of Asia, where, amid widely differing surroundings different forms have been developed.

The first sorghum grown in America was doubtless the so-called Guinea corn, brought from Africa to the West Indies sometime before 1707. Broom corn sorghums were grown in Virginia and probably elsewhere in Colonial days, but sweet sorghum was not introduced until 1853 when it came from China by way of France under the name of Chinese Sorgo. Since 1850 numerous varieties have been introduced into the United States by the U. S. Department of Agriculture and other agencies, and the crop has become one of much importance.

Climate and Soil Required

As a group the sorghums are distinctly drought-resistant and are able to thrive in regions much too dry for corn. For this reason they have replaced corn in the semi-arid regions of southwestern United States and have even extended the grain-growing area of that region into sections where corn cannot be grown.

This character of drought resistance seems to be due to the plants' ability to stop growth and assume a dormant condition in times of severe drought, and then recover with the coming of more favorable weather. It thus differs from corn which makes a steady growth and is never able to recover, once its growth is interrupted.

Like corn, sorghum is a warm-weather plant but is even more sensitive to cold at both ends of the season than is corn. For this reason it cannot be planted in the spring until all danger of frost is past and the ground thoroughly warmed, and it must be mature before the first frosts in the fall. Its culture, as a rule, is confined to the region south of the 37th parallel although some of the earliest maturing forms are grown much farther north.

Like most other crops, sorghum does best on fertile soil but it is not so sensitive to unfavorable conditions and will frequently produce good yields on soils too thin for corn. In those regions where both corn and sorghum are grown it is customary to plant sorghum on the poorest fields and save the best for corn. It does not respond as well to a good seedbed or to the use of manures and fertilizers as does corn; in fact, fertilizers are seldom, if ever, used with it. Like rye and buckwheat, sorghum might well be called the poor man's crop for no other plant will produce such large returns, especially of forage, on poor land with as little care.

Types and Varieties

The numerous types of sorghum that have been developed may be classified according to use as follows:

- I. Saccharine (sweet) Sorghums
  - 1. Sorgo or Common Sorghum (for syrup and forage)
- II. Non-Saccharine Sorghums
  - 1. Grass sorghums (for forage)
    - a. Sudan grass
    - b. Tunis grass
  - 2. Grain sorghums (for grain and forage)
    - a. Kafir
    - b. Durra
      - 1. Milo
      - 2. Feterita
    - c. Shallu
    - d. Kaoliang
  - 3. Broom corn sorghums (for brooms)

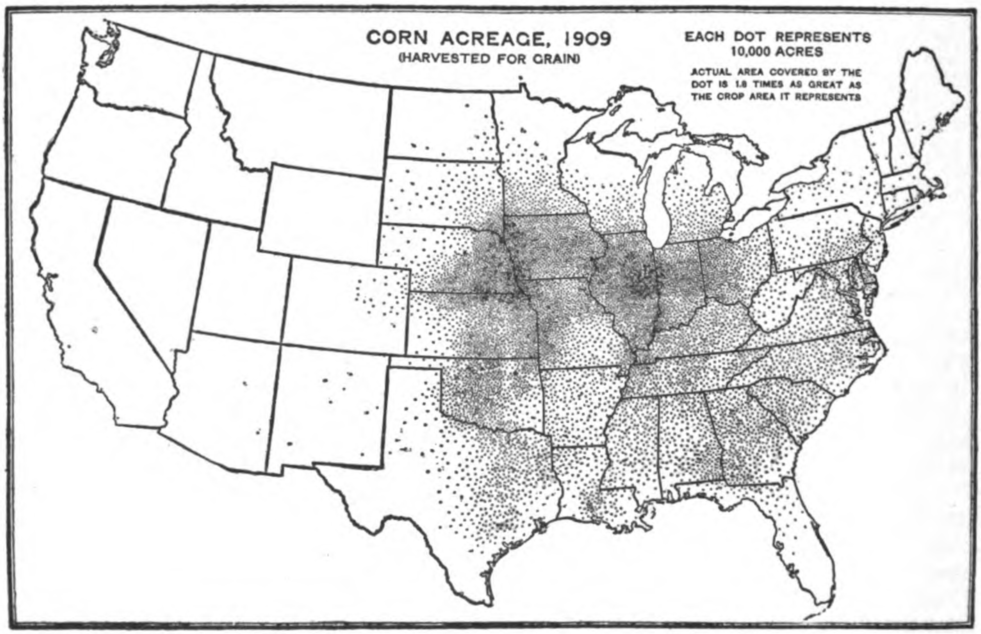


FIG. 243. The acreage of corn is increasing in the South, but the Corn Belt holds its own as the world centre of one of the greatest of agricultural activities. (1915 Yearbook, U. S. Dept. of Agr.)

The Saccharine sorghums have juicy stems from which syrup is made. They are also grown extensively for forage, being used as hay, fodder, or silage.

For fodder or silage sorghum is drilled in rows with a corn planter using specially designed planter plates, at the rate of 6 to 8 pounds of seed per acre. The crop is cultivated like corn and harvested by hand or with a corn binder.

For hay it may be drilled in narrow rows or sown solid with a grain drill. It is sometimes sown broadcast but this is not a good practice as more seed is required and the stand is usually uneven. One to one and a half bushels of seed are required where drilled solid. The heavier the seeding the finer the stems and the better the quality of hay. It is mown and cured like a heavy grass crop or may be bound in small bundles with a grain binder and cured in small shocks. Some difficulty is often experienced in curing, especially in wet weather, on account of the heavy, juicy stems. In general, 3 to 6 tons of hay or fodder and 8 to 10 tons of silage is a good yield. When properly cured it is equal in feeding value to timothy hay and corn stover, while it ranks next to corn as a silage crop.

Sorghum is sometimes pastured but great care must be exercised in using the crop in this way since under unfavorable conditions, deadly prussic acid often develops in the growing plant. Animals are frequently killed in a very few minutes by being turned into a field in which this had taken place. The poisonous compound changes to a harmless form after a very slight wilting of the plant so that a crop known to contain the poison may be cut, cured for hay and fed with complete safety.

Sweet sorghums are grown chiefly south of the Ohio and Missouri rivers and east of the western boundary of Missouri, Arkansas, and Louisiana. Their principal varieties are:

Amber, the most popular variety grown; matures in 90 to 100 days; medium height (from 5 to 7 feet) with 8 to 10 leaves. The seed head is usually black to very dark amber, loose and spreading with reddish-yellow grains. Very popular for forage because of its slender stems and early maturity. Developed in Indiana from the Chinese sorgo.

Orange matures in 100 to 125 days; taller and heavier than the Amber and more leafy; has a compact head, orange colored when ripe. Makes a heavy growth especially on rich land and is difficult to handle as forage. Excellent variety for syrup. Introduced from Natal (Africa) in 1857.

Sumac, a late variety with compact, red-seeded head. Very similar to the Orange but larger and later. Especially popular for syrup in the South where the long seasons permit it to mature. Introduced from Natal in 1857.

Goose Neck, a large, late-growing variety adapted only to the South. Compact, egg-shaped heads 5 to 9 inches long most of which hang over at maturity; black hairy glumes, reddish yellow grains; about one week later than Sumac. Known since 1876 and probably introduced from Natal.

Honey, a large, late-maturing variety with very sweet and juicy stems; loose, open head 9 to 11 inches long, with dark brown grains. Found growing in Texas in 1904 but its early history is uncertain.

The grass sorghums are recent additions to American agriculture. Sudan grass, introduced by the United States Department of Agriculture in 1909, is by far the more important. It has proved especially valuable as a forage crop in the Southwest, and its culture is spreading rapidly in that region. On account of its larger yields it is replacing millet on the farms of the Middle West and is being grown to some extent even in the humid region of the country. Tunis grass has not as yet been grown to a sufficient extent to determine its agricultural value in this country.

Sudan grass is sown broadcast, in rows or drilled solid, the latter method being preferable where there is sufficient moisture and where it is grown for hay. For drilling or broadcasting 15 to 20 pounds of seed to the acre are necessary; for drilling in rows 3 to 5 pounds are sufficient. For seed production thin seeding in rows is advisable.

For hay the crop is mown, cured and handled like millet or, if not too rank, it may be cut with a grain binder. For seed it is usually cut with a grain or corn binder. Toward its northern limit the crop is cut only once, but southward 2 or 3 cuttings may be had, depending on the season and time of cutting. For hay it is best cut when in full bloom. Single cuttings usually yield from 2 to 3½ tons to the acre, while 2 or more cuttings in a season may total 4 or 5 tons of cured hay. Yields of seed range from 5 to 12 bushels depending upon the soil, moisture conditions and method of seeding. No varieties have been developed.

The Grain sorghums. These are very generally cultivated throughout Africa, southwest Asia, India, and Manchuria where they are commonly used as human food. In general, the Kafirs are most important in southern Africa, the Durras in northern Africa and southwestern Asia and India and the Kaoliangs in Manchuria. Shallu, the least important of the five types, is a winter crop in India.

Kafir (also called Kafir corn) comes from the colony of Kafir in South Africa. It was first introduced into America in 1876 in California but was not generally distributed until about ten years later. The three principal varieties are Red, White, and Blackhull Kafir. The first two were brought to this country at an early date but the latter has never been grown ex-

tensively owing to the fact that the heads often remain enclosed in the upper sheath and tend to mold and decay. Red Kafir matures well and produces good yields of grain. In common with all red-grained varieties, its seeds contain a large amount of tannin which gives them a sort of bitter taste which is considered objectionable by growers. The Blackhull, a variety with white seeds and black glumes, was introduced in 1896 and has practically replaced the red variety since it possesses all of the advantages of the latter and at the same time is practically free of tannin.

Red Kafir has long, slender heads 12 to 18 inches in length with dark red grains enclosed in yellowish to dark green glumes. The heads of Blackhull Kafir are more compact ranging from 10 to 14 inches in length. Pink Kafir, recently introduced from Africa, is, in many respects, intermediate between the Blackhull and Red varieties.

Durra (dura, durah, doura, dhoura, etc.). This is the most important type of grain sorghums in the old world. The reare three general durra groups only one of which is sufficiently early maturing to be of value in the United States. This group contains a number of varieties of which the most important are Milo and Feterita. Milo often called Milo maize, came into general notice about 1890 but was first introduced into the United States about 1885 by a Georgia seedsman and probably first grown in southern California or Georgia. It probably came from Africa though nothing exactly like it has been found in that country. It is characterized by its stout rather pithy stems; dense ovate heads, nearly always recurved; dark colored glumes; awned florets; and pale yellow grains. A dwarf variety with upright heads has been developed and is now grown extensively. A white-seeded form has also been developed in Texas. As a rule it is about 3 weeks earlier than the Kafirs, maturing in 90 to 100 days.

Feterita, another durra, was introduced in 1906 from Sudan. It differs from milo chiefly in having erect, cylindrical and dense heads but not so compact as in milo; also in having larger, bluish-white grains, with black, shiny glumes which half enclose the seeds. It is about a week earlier in maturing than milo.

Other less important varieties are the Brown and White Durras, introduced into California in 1874. White Durra is commonly known as "Jerusalem Corn" and sometimes as "Egyptian Rice Corn," Brown Durra is sometimes called "Egyptian Corn" and both are also known as "California Corn" or "California Wheat." Brown durra is the most important of the two, being grown to some extent in southern California and Texas.

Shallu was first imported from India by the Louisiana Experiment Station about 1890. After shown by trial to be inferior to other sorghums for forage, it was discarded by the station. But in the farmers' hands it persisted and was gradually carried westward into Texas and Oklahoma where it has acquired many names such as California Wheat, California Rice Corn, Chicken Corn, Chinese Golden Sorghum, Egyptian Rice, Egyptian Wheat, Mexican Wheat and Rice Corn. Like most of the Asiatic sorghums, it has a large, open, pale yellow head with white or yellowish seeds. There is only one variety in the United States. It has been widely advertised, and extravagant, false claims have been made for it. It is probably inferior to both Kafir and Milo.

The Kaoliangs, of which there are several varieties, have come from China and Manchuria since 1901. The name Kaoliang (or Kowliang) is Chinese for "tall millet" and was given it to distinguish it from the common smaller millets of that region—the sorghums being commonly classed as millets in both India and China. The Kaoliangs came from a region of 38° to 42° north latitude, are early maturing, and are adapted to use farther north than the other grain sorghums. They have been introduced by the Department of Agriculture for trial in the northern part of the Great Plains region where the seasons are too cool for the other grain sorghums, but they have not become important farm crops as yet.

Cultural Methods

The grain sorghums are grown much the same as corn and occupy the same place in the rotation. Land is prepared as for corn and the seed is usually drilled in rows about 3½ feet apart with an ordinary surface corn planter or with a lister, and dropped 6 or 8 inches apart in the row. Kafir is usually planted thinnest, Milo somewhat thicker and the Kaoliangs still thicker. From 3 to 5 pounds of seed are needed per acre.

The crop is cultivated like corn, but the method of harvesting depends upon how it is to be used. Where the whole plant is saved it

FIG. 244. A field of Kafir showing mature seed heads

may be cut by hand or with a corn binder; where only the heads are harvested, they are cut by hand or, in the case of dwarf varieties, with a header. Erect headed and dwarf varieties are preferred for grain because they are more easily harvested. The heads are then stored until dry and threshed with an ordinary grain thresher. Unless dry when stored, grain is liable to heat and become damaged.

As a rule the Durras are better adapted for grain production and the Kafirs for forage or silage. Milo is perhaps the best of all for grain although in recent years Feterita has become very popular. Blackhull Kafir probably ranks next in importance.

The feeding value of the grain sorghums compares very favorably with corn and the other cereals, though the food nutrients, especially the carbohydrates, are said to be somewhat less digestible.

The accompanying table from the Journal of the American Society of Agronomy and Farmers' Bulletin 686, gives the average composition in percentages of the more important types as compared with some of the other cereals.

Yields. According to the United States census the average acre yield was 19.4 bushels in 1899 and 19.8 bushels in 1909. Good yields range from 25 to 40 bushels and sometimes go as high as 70 or 75 bushels an acre. The leading grain sorghum states are Kansas, Oklahoma, Texas, and California.

GRAIN	WATER	ASH	PROTEIN (N X 6.25)	FAT	FIBER	CARBOHYDRATES
Durra, 39 samples	9.50%	1.73%	13.63%	3.47%	1.49%	70.30%
Kafir, 182 samples	9.37	1.87	13.37	4.23	1.36	69.84
Milo, 150 samples	9.39	1.64	12.50	3.18	1.52	71.88
Shallu, 10 samples	10.36	1.98	15.19	3.69	1.93	66.84
Feterita, 8 samples	9.58	1.72	14.00	2.90	1.48	70.32
Maize, 114 samples	10.04	1.55	10.39	5.20	2.09	70.69
Wheat, 166 samples	10.62	1.82	12.23	1.77	2.36	71.18
Oats, 133 samples	7.10	3.50	14.87	4.52	10.10	59.91
Barley, 84 samples	8.71	2.98	11.86	2.02	5.76	68.98
Rye, 57 samples	8.67	2.09	11.32	1.94	1.46	74.52

Broom Corn

Broom corn differs from the other groups of sorghums in bearing seed heads with much larger, straighter, stronger branches or straws which are used for making brooms.

Three varieties are grown in this country: the Standard, Dwarf, and Acme (Dwarf Standard). The Standard grows to a height of 10 to 15 feet, produces a heavy brush 18 to 28 inches long and is used in the manufacture of medium to heavy carpet, warehouse and stable brooms. The Dwarf variety grows from 4 to 6 feet high, has a large amount of foliage, and produces a fine brush 10 to 18 inches or more in length. Probably two-thirds of the total crop of the United States is of the dwarf type. Its straws are weaker, less elastic and hence not so good for making heavy brooms. It is used chiefly for hearth and whisk brooms, the highest grade best suited for the making of fine clothes brooms commanding the highest market prices. For this purpose the straw should be fine, straight, tough, elastic, of a uniform green color without red tints and from 10 to 12 inches long. The Acme, recently developed by the United States Department of Agriculture but not grown commercially, is a dwarf but produces a brush much like the Standard.

Soil and climate required. Any soil that will produce a good crop of corn is sufficiently fertile for broom corn. Light, sandy types as in Oklahoma and Kansas are preferred for the highest quality dwarf type of brush, and richer and heavier soils like those of the Mississippi Valley for the Standard.

Climate is even more important than soil. Being a subtropical plant broom corn does best in warm climates. At the same time, in order that the crop may be harvested at the proper time and in good condition, and the brush dried rapidly so that it will retain its fresh, green color, warm, dry weather is necessary at harvest time.

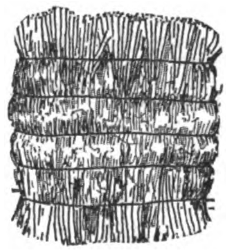


FIG. 245. A bale of broom corn

How to grow it. General practices are about the same as for corn. More care in securing good seed is necessary, however, with broom corn than with most crops, since much of the seed on the market coming from the threshers is very poor. Furthermore, much of it is produced in the humid sections and is not adapted to the drier regions farther west where most of the broom corn of the country is grown. Let each grower pro-

FIG. 246. Broom corn head carrying seed

duce his own seed, if possible, selecting it from plants that ripen uniformly; otherwise get it from a reputable grower in his locality.

Broom corn is planted in rows 3½ to 3½ feet apart and about 6 or 8 inches apart in the rows. About 2 quarts of seed to the acre are required. Planting is done with a surface planter or with a lister, and usually about 2 weeks later than the general corn planting in the locality.

Harvesting. The market demands a brush of bright yellowish green color and high quality. To secure this the plants should be harvested while in bloom or when the anthers are falling from the heads. If seed is allowed to ripen the brush becomes brittle and loses value.

The brush of the dwarf type is usually pulled by hand, placed in convenient piles on the ground or piled between two plants until it can be removed to the curing shed. The greater height of the Standard type makes it necessary to bend the heads over before harvesting. This is done by an operator who walks backward between two rows bending the heads over first from one row and then from the other in such a way as to form a "table" of a convenient height. Another operator then passes down between 2 tables cutting off the heads with a sharp knife 6 or 8 inches below their bases. All of the heads cut in a day should be hauled to the curing shed before night. The following morning they are taken to the threshing machine and the seeds scraped off without breaking the straw. The brush is then placed in thin layers on racks or shelves in the shed to cure, away from direct sunlight to preserve the color and quality. After curing for 3 or 4 weeks the brush is sorted, graded and bound in bales of 300 to 400 pounds each for the market. Sometimes it is cured in ricks in the field but an inferior quality usually results. The decrease in value of field-cured brush is frequently great enough on a few acres to cover the cost of a curing shed.

Production. According to the 1910 census the four states of Oklahoma, Illinois, Kansas and Texas produced 93 per cent of all the broom corn of the United States. The total crop of 1909 was 78,959,958 pounds produced on 326,102 acres and valued at $5,134,434. During the last forty years the market price has varied with the supply and grade from $25 to $250 per ton. Normally good brush brings from $75 to $100 a ton. But very little is exported.

The cost of production up until harvest is about the same as for corn. The extra labor in harvesting, threshing, and baling is estimated at $4 or $5 an acre. Successful growers in Kansas and Oklahoma estimate the total cost at from $35 to $50 a ton.

B. THE SMALL GRAINS

By J. C. HACKLEMAN, *Assistant Professor of Farm Crops, University of Missouri. He was born on a farm in Central Indiana and graduated from the College of Agriculture of Purdue University in that state. While studying for an advanced degree at the University of Missouri, he was Assistant in Agronomy until 1913, when he assumed his present position. He is a member of the American Society of Agronomists and of the honorary agricultural society, Alpha Zeta. At the present writing he is also secretary of the Missouri Corn Growers' Association, which was organized by Professor Hutchinson who wrote on the Corn Crops* (*Section A of this chapter*)—EDITOR.

THE small grains include the oldest of cultivated crops—those upon which man first depended when he progressed from the wandering pastoral stage of his existence to the higher agricultural stage. They include also some of the most important sources of human food—the staples upon which, it may be said, the actual sustenance of nations depends. The successful production of any one of these crops in these days of high-priced labor, seed, fertilizer, etc., has become a more difficult as well as a more vital one. The man who can succeed is he who knows his crop best by long, close experience and study. The following discussions attempt to summarize very briefly what such experience tells us. They are a foundation upon which to build a personal knowledge, a firm base upon which to rear a safe, efficient program.—EDITOR.

BARLEY. Barley, one of the oldest of cultivated crops, was commonly grown among the ancient Egyptians. It is recorded in the early history of Egypt, and specimens of it, as also of wheat, have been found in the old tombs. The exact place of origin of the crop is not known, but it is thought that it was first grown in western Asia. Barley was distributed widely over Europe and Asia, as it was the most important bread or flour crop for centuries. In fact, until comparatively recent times, barley has been to Europeans the important flour-producing cereal. Not until the greater use of wheat and potatoes crowded the barley out, did it cease to occupy its significant position.

Types. Barleys may be divided into 2 classes, the 2-rowed and the 6-rowed. This difference in appearance is due to the fact that in the 2-rowed only the middle of the 3 grains per spikelet developed, while in the 6-rowed all grains developed, and, since the spikelets appear on both sides of the rachis, or zigzag axis, the appearance is that of 6 rows.

A further classification is that based upon the time of growth, whether winter or summer. The winter barley, which is fall-sown and ripens at about the same time as spring-sown, is not as extensively grown as winter wheat, because the crop is not sure. Winter barley is found chiefly in the South and Southwest.

Barleys are classified also with reference to their bearded tendencies.

Adaptation. Barley is naturally adapted to a temperate and warm climate and can stand very dry conditions. Unlike wheat, oats, and corn, barley can endure short rainfall, and grows well in dry regions. In fact, it demands less water than either of the 3 cereals mentioned.

While the natural adaptation is to temperate regions, barley grows well in cool sections, also, where corn makes but a moderate growth. The more hardy of the early-maturing spring barleys are successfully grown as far north as Alaska. The winter barleys are not so hardy as the winter wheats and are, therefore, limited broadly to the cotton belt.

Barley finds its best growth on well-drained loams, but makes satisfactory growth on many other kinds of soil. The range in soil varies from the rich, well-drained loam to the alkali soils of the northwestern part of the United States. Barley seems to do as well as, if not better, on these soils than any other common cereal. This fact makes possible a large grain-producing region which might not otherwise be of any consequence in the production of cereals.

Cultural methods. Cultural practices for barley will necessarily be governed by the time of seeding, whether in fall or spring, and also upon the preceding crop. For fall-seeded barley, a carefully prepared seedbed should be used, as the crop needs every advantage. If the crop follows a sod crop or a crop where the soil is not clean of weeds and organic matter, the land should be plowed. If soy beans, corn, or other cultivated crop preceded, the disc harrow may prepare a good seedbed.

Spring-seeded barley, also, should have a good seedbed, by plowing the land either in the fall or as early in the spring as possible. In the former case, a disc harrow will nearly always prepare the land in fine shape. More care should be exercised than in seeding oats, as the crop is injured by an inferior seedbed. By seeding time, the land should be free of trash (undecayed organic matter), worked down, with a mellow surface soil above a firm subsoil. Seeding should be done with a drill, and the seed should be sown at the rate of 5 to 8 pecks. The seed sown should be clean, plump, and free of all weeds and organic matter. Many farmers broadcast barley. When this is done, at least a half bushel of seed should be added, to allow for that which does not grow, because it is never covered.

Harvesting and threshing. Barley should be harvested when the straw and heads have turned to a yellow color. Earlier harvesting creates a shriveled, wrinkled condition which is objectionable on the market. After cutting, barley should be well shocked to protect it from the weather, as weathered, discolored, or stained barley never secures the best prices. Threshing should be done just as soon as the bundles dry out thoroughly. This involves the minimum amount of discoloration, and usually insures a better grade and price.

Commercial classes and grades. The 4 officially recognized classes of barley are as follows:

Barley, Nos. 1, 2, 3, 4, and 5; *Scotch barley*, Nos. 1, 2, and 3; *Bay brewing barley*, Nos. 1, 2, and 3; *Chevalier barley*, Nos. 1, 2, and 3.

The requirements of the grades are:

No. 1 Barley shall be sound, plump, bright, clean, and free from other grain.

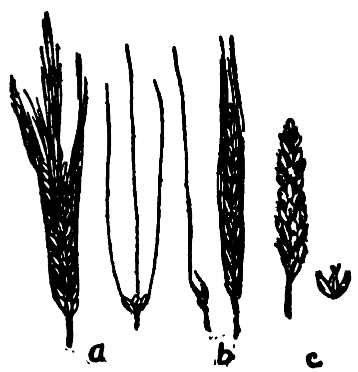


FIG. 247. Types of barley showing a head (spike) and a single spikelet of each: *a* 6-row, *b* 2-row, each bearded; *c* beardless.

No. 2 Barley shall be of healthy color, not sound enough and plump enough for No. 1, reasonably clean and reasonably free from other grain.

No. 3 Barley shall include all barley slightly shrunken and otherwise slightly damaged barley, not good enough for No. 2.

No. 4 Barley shall include all barley fit for malting purposes, not good enough for No. 3.

No. 5 Barley shall include all barley which is badly damaged, or from any cause unfit for malting purposes, except that barley which has been chemically treated shall not be graded at all.

Scotch, Bay brewing, and Chevalier barleys must conform to variety. They show only the first 3 grades. Bay brewing and Chevalier must be grown in Western states. Taking corn, which leads in production, as a standard, about one twenty-fifth as much barley is produced, compared to one half as much wheat and one third as much oats.

Of the world's total crop of about 1 billion bushels one ninth is produced in America and seven ninths in Europe, where Russia leads with almost 400 million bushels or one third of the world's crop.

Use and distribution. Barley is used in the United States mainly for brewing purposes and for stock food. In some regions it takes the place of corn as the chief food for stock. Barley is grown much more extensively in Europe than in America. Russia is the greatest producer, having nearly one half the world's acreage.

BUCKWHEAT. Buckwheat is not a cereal though commonly considered one. In reality it belongs to the dock family, which includes curled dock, sorrel, and smartweed. It is classed as a cereal only because of its extensive use as human food. All true cereals have a fibrous, much branched root system, while buckwheat has a taproot. This enables the plant to go to great depths for water, giving it its drought resistance.

In Europe buckwheat has been grown as a cultivated crop for many centuries. In this country, however, its history dates back only to Colonial times. Since its introduction into the United States, however, it has held a minor but important place as a flour-producing grain crop. This was especially true in Colonial days, and its greatest production is still found in the Eastern states, where it was first introduced and used.

Types and varieties. Two types of buckwheat are found in the United States, the Common and the Tartary. There are three important varieties of the former, the Japanese, Silverhull, and Common Gray. The Tartary is less commonly grown, being adapted to a somewhat colder climate, as found in Canada, Maine, and other Northern states.

Adaptation. Buckwheat, while it may be grown as far north as Maine and portions of Canada, is not hardy like rye, oats, and other cereals, but is quickly killed by frosts and freezes. Because of its very short growing season, 65 to 85 days, buckwheat may be grown in Canada and yet escape frosts. Soil adaptations are not exacting and the crop is found growing successfully on a wide variety of soils. Buckwheat will produce a satisfactory crop on impoverished and poorly cultivated lands where other grain crops would have failed. Like all other crops, however, it produces better yields on the more fertile and better-tilled soils. Buckwheat seems best fitted to produce its maximum on well-drained, medium fertile sandy loam or light clay loam soils. On rich soils and those rich in nitrogen, it lodges, like wheat and oats.

Cultural methods. The seedbed for buckwheat is as a rule hastily and poorly prepared. Since the crop is frequently used as a catch crop, very little time is left for seedbed preparation, yet more care would prove profitable. The land should be plowed and prepared as long ahead as possible, so as to give the seedbed time to settle, and the seed should then be sown in the mellow surface soil. This early preparation will insure more moisture, which is often the deciding factor in the production of buckwheat.

The seeding of buckwheat should be done late in the spring after all danger of frosts is past. The seed should be sown at the rate of 4 or 5 pecks per acre and drilled in. Broadcasting and harrowing in is common, but drilling will usually give better results.

Harvesting and handling. The harvesting of buckwheat has not been modernized by machinery as has that

WORLD BARLEY PRODUCTION, 1914

LEADING COUNTRIES	ACREAGE	PRODUCTION IN BUSHELS	PER CENT OF WORLD'S PRODUCTION
Russia	30,872,000	403,023,000	27.54
United States	7,565,000	194,953,000	13.32
German Empire	3,909,000	144,125,000	9.84
Austria-Hungary	4,434,000	128,663,000	8.79
Japan	3,294,000	85,835,000	5.86
United Kingdom	1,870,000	66,637,000	4.54
Canada	1,496,000	36,201,000	2.47
Algeria	3,131,000	35,785,000	2.46
World		1,463,289,000	100.

UNITED STATES BARLEY PRODUCTION 1916

LEADING STATES	ACREAGE	PRODUCTION IN BUSHELS	AVERAGE YIELD PER ACRE		AVERAGE FARM PRICE PER BUSHEL	
			(1916)	(1907–16)	(1916)	(1907–16)
North Dakota .	1,725,000	26,738,000	15.5	20.1	$ .80	$ .53
Minnesota . .	1,375,000	26,125,000	19.0	23.6	.87	.60
California . .	1,190,000	33,320,000	28.0	28.1	.95	.72
South Dakota .	825,000	18,728,000	22.7	21.4	.83	.56
Wisconsin . .	610,000	18,300,000	30.0	28.0	1.05	.69
U. S. . . .	7,674,000	180,927,000	23.6	25.2	$ .88	$ .62

of wheat and oats. The cradle is yet a common method of harvesting. The buncher or self-rake on the mowing machine may also be used. Binders are used, but not so extensively as for other cereals. Buckwheat should be cut before the first freeze kills the plants. After cutting and bunching in small shocks, which are not capped, the buckwheat is allowed to cure or dry out until it is sufficiently dry to thresh out readily.

FIG. 248. Japanese buckwheat: *a* grew on land cultivated in the spring; *b* on land where weeds grew all spring; both plots were fitted the same before seeding.

Threshing is done by hand, by flail, and by threshing machines. The thresher is more commonly used and will do the work very satisfactorily if the speed is reduced, the concave bearing the teeth removed, and a blank substituted.

Distribution. Europe produces by far the greater portion of the world's buckwheat supply. The northeastern states produce the crop of the United States.

FLAX. Flax is an annual plant and among the oldest of cultivated crops. It is really a fiber plant, and is grown as such in Europe; but in the United States it is grown almost entirely for seed, and for that reason is here classed among the grain crops. The fiber varieties grow to a height of 4 feet, but those which have been developed solely for seed-production range from 1 to 2 feet. It is especially well suited to the cool nights and warm days of temperate countries such as northern United States, southern Canada, Argentina, and central Russia, ripening in 10 to 12 weeks. A compact soil, rich in soluble and easily available organic matter and containing sufficient moisture, is necessary, because the root system is limited and comparatively frail. The soil character seems however of not much importance; for good crops are grown both on light sand and on heavy clay, *if correctly handled.* A deep, moist loam or clay loam, however, has given best results. In the great flax-producing region of the Dakotas, Montana, and Minnesota, which produces more than 90 per cent of the total yield of the United States, flax is generally used as a "breaker" crop; for, unlike the cereal grains, it will give good yields when seeded directly upon newly-turned sod that has simply weathered, packed, and rotted sufficiently to provide a firm seedbed. For this reason it is the first money crop of the homesteader. Upon older land it follows a legume crop or hay or pasture sod in a long-period rotation. The serious damage resulting from flax wilt has usually made continuous cropping unprofitable.

Types and varieties. Both small-seeded and large-seeded types occur, and each of these contains blue-flowered, white-flowered, and specialized fiber and seed-producing varieties. White-blossomed Dutch and Russian Riga are the best known. Wilt-resistant varieties have recently been developed by selection, and these have done much toward making continued flax-raising profitable.

Cultural methods. Though most commonly seeded upon newly broken sod, a deeper and better seedbed is secured by breaking sod 3 inches deep in the spring and backsetting 6 or 7 inches deep in the early fall. Medium deep plowing is customary, and all future disking and harrowing is done with the intention of forming a firm, well-packed seedbed, for none of the other grain crops require this so much as flax.

Seeding. Unless flax is to be sowed upon new land, it is best to use wilt-resistant seed. Old land is usually infected with flax wilt, and reduced yields or total failures result from the use of common seed not resistant to this disease. In any case it is best to select plump, heavy, bright seed and treat with formalin (Chapter 34).

The date of seeding varies with the length of the growing season between frosts, but from May 10 to June 10 is customary; drilling

UNITED STATES BUCKWHEAT PRODUCTION 1916

LEADING STATES	ACREAGE	PRODUCTION IN BUSHELS	AVERAGE YIELD PER ACRE		AVERAGE FARM PRICE PER BUSHEL	
			(1916)	(1907–16)	(1916)	(1907–16)
New York . .	290,000	3,480,000	12.0	19.0	$1.22	$ .78
Pennsylvania .	270,000	3,780,000	14.0	19.6	1.11	.74
Michigan . .	75,000	825,000	11.0	15.3	1.15	.73
West Virginia .	36,000	659,000	18.3	21.3	1.01	.81
Virginia . . .	25,000	480,000	19.2	19.2	.95	.78
Wisconsin . .	20,000	280,000	14.0	15.3	1.16	.79
Ohio	19,000	336,000	17.7	20.0	1.10	.80
New Jersey . .	15,000	285,000	19.0	20.5	1.08	.79
Maine . . .	14,000	336,000	24.0	28.9	.95	.70
Vermont . .	12,000	210,000	17.5	24.2	1.05	.79
U. S. . . .	845,000	11,840,000	14.0	19.5	$1.12	$ .76

should be at the rate of 2 to 3 pecks per acre, and 1 inch deep. Broadcasting is uncommon and not favored, because with it uniform depth, which is extremely important, is impossible. Too deep seeding compels the young plants to waste all their stored energy before they reach the surface, causing uneven stands, irregular maturity, and reduced yields and quality.

Harvesting. Where grown purely for seed, the crop is harvested with the self-binder. The shocks are made loose and small, to allow further ripening and drying. Threshing is the same as with any other grain crop; but, unless thoroughly dried and cured, flax cannot be threshed to advantage, the straw tangling around the cylinder teeth and the bolls refusing to open and shell out. Good yields range from 10 to 12 bushels per acre, but, because of the high average price, lower yields, also, may be profitable.

Use. Flaxseed is the source of linseed oil, used in paint and varnish making and in medicine, and it is almost solely for this purpose that the crop is grown in the United States. Except in small regions of Michigan and Oregon, fiber production is not considered, though some threshed flax straw is sold for papermaking, etc., and this may in time become more important. The high cost of labor, however, will prove a great hindrance, unless a machine for flax-pulling is perfected.

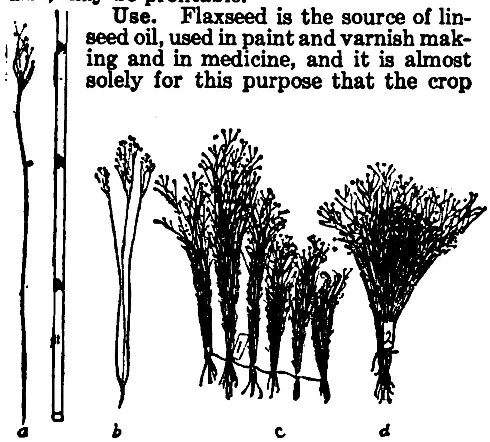


FIG. 249. **Flax:** *a* and *b* are typical plants of the fibre and seed-yielding types; *c* and *d* are groups of seed plants the former showing wide variation, the latter marked uniformity. (Farmers' Bulletins 274 and 669).

In Europe, especially in Russia and Austria-Hungary, flax is grown almost solely for fiber. Tall, nonbranching varieties, low in seed-production but high in quality and quantity of fiber, have been developed. Cultural methods up to harvest time are similar to ours except that seed is usually broadcasted and the rate of seeding is much more liberal, to encourage upright growth and improve quality. Plants are pulled (uprooted) by hand and carefully dried, sometimes in shocks, but more often by hanging upon poles. To prevent damage to the straw, the seed is removed by hand or by means of a simple machine. The straw is then either spread out upon the ground and exposed to dew and rain or submerged in running water for 3 weeks or more, to undergo a process of fermentation known as "retting." The straw is then dried and the fiber separated from the bark and woody portion of the stem by "breaking" and "scutching"—processes which break the brittle portion of the stems, making possible its separation from the tough, flexible fibers by beating with small paddles. Glancing blows knock off all foreign matter and leave only the cleaned fiber. Sorting, baling, and grading prepare the fiber for market, grading requiring long training and experience.

OATS. The oat plant is not so old as either wheat or barley, and more is known of its early history. The present plant is doubtless a selection from one of the wild forms which are found growing in many parts of this country and in Europe.

Oats, like wheat, when grown under wide variations of climate and soil, have gradually been influenced by environment and husbandry until there are to be found in the world 8 more or less distinct and peculiarly characteristic types. Nearly all of these are of no special economic value, and embody largely the wild forms of European countries and America.

The common forms *Avena sativa* and *Avena sterilis* form the basis of practically all of our common cultivated species of oats, the greater number of varieties of the common oats of both America and Europe tracing back to the former (*A. sativa*).

Varieties of oats. Oats, like wheat, have been cultivated over a wide range of soil and climatic conditions with the result that there is to be found an exceedingly long list of varieties, many of which are really the same, but distributed under different names.

Additional confusion has been caused by giving one and the same variety a different name when grown as a winter oat from that assigned to it when grown as a spring oat. The same varieties are frequently interchanged, the winter oat being used as a spring oat, and in some cases, the spring oat being taken south and used as a winter type.

Among the spring varieties with light yellow to white grain the Silvermine, Swedish Select, Early Dakota, Lincoln, and Canadian are the more common. Those having light to yellow-colored grains are Kherson, Early Champion, and Sixty Day. The common varieties having black to brownish-red grains are Victor, Joanette, Monarch, and Black Diamond. Those having dark-yellowish or brownish-yellow grains are Burt and Red Rustproof. This list does not represent all of the types, but gives examples of the more important varieties of each color found in spring oats. Among the more important varieties of winter types may be mentioned Turf, Culberson, and Fulghum.

Adaptation. The oat, perhaps more than any other cereal, is almost wholly dependent upon seasonal conditions. Adapted to a cool, moist, short season, the oat plant will not

FIG. 250. Pulling flax for fibre (Farmers' Bulletin 669)

produce satisfactory results regardless of soils, fertility, and seedbed preparation when subjected to hot, dry weather. Long winters, cool to cold seasons, and short summers with abundant early moisture are the climatic conditions under which oats thrive. For this reason the northern tier of states in the United States and nearly the whole of Canada and parts of Alaska are the oat-producing sections of America. Even as far north as northern Iowa, Illinois, and Indiana the oat crop is influenced by heat, and it frequently happens that the oat crop is injured by a dry, hot period during the latter part of the short growing season.

Soil requirements. The soil requirements of oats are perhaps of less consequence than those of any other farm crop. Almost any type of soil, even a poor one, will produce a good yield of oats, if abundant moisture is available. Rainfall is more important than soil fertility, since oats require more water than almost any other farm crop and considerably more than corn or wheat.

Rich soils, especially those high in nitrogen, should be avoided, as the crop is likely to make very rank growth under such conditions and would, doubtless, lodge badly, producing little, if any, grain.

Owing to this peculiar habit of the oat plant to produce a crop more or less independently of the fertility of the soil, fertilization has never been widely practised. The

WORLD PRODUCTION OF FLAX, 1913

FOR SEED				FOR FIBER			
LEADING COUNTRIES	ACREAGE	PRODUCTION (bushels)	PER CENT OF PRODUCTION	LEADING COUNTRIES	ACREAGE	PRODUCTION (pounds)	PER CENT OF PRODUCTION
Argentina	4,283,000	44,486,000	33.58	Russia .	3,675,000	1,152,349,000	83.22
Russia .	3,675,000	24,456,000	18.46	Austria .	......	88,615,000	6.39
India . .	4,558,000	21,684,000	16.36	France .	75,000	48,437,000	3.49
U. S. . .	2,291,000	17,853,000	13.47	Belgium	57,000	39,437,000	2.84
Canada .	1,553,000	17,539,000	13.22	Ireland .	59,000	28,341,000	2.04
				Holland .	36,000	16,606,000	1.19
World total	....	132,477,000	100	World total	....	1,384,757,000	100

FLAXSEED PRODUCTION IN UNITED STATES, 1916

LEADING STATES	ACREAGE	PRODUCTION IN BUSHELS	AVERAGE YIELD PER ACRE		AVERAGE FARM PRICE PER BUSHEL	
			(1916)	(1907–16)	(1916)	(1907–16)
North Dakota	790,000	8,137,000	10.3	8.3	$2.52	$1.58
Montana	325,000	3,088,000	9.5	10.0	2.48	1.53
Minnesota	275,000	2,338,000	8.5	9.4	2.40	1.57
South Dakota	150,000	1,195,000	9.8	8.4	2.47	1.54
Kansas	30,000	174,000	5.8	6.4	2.34	1.45
Iowa	18,000	180,000	10.0	10.2	2.15	1.47
Wisconsin	5,000	60,000	12.0	13.2	2.40	1.55
Missouri	5,000	35,000	7.0	7.0	2.12	1.38
Nebraska	4,000	32,000	8.0	8.5	2.30	1.47
Wyoming	2,000	14,000	7.0	9.8	2.25	....
Colorado	1,000	6,000	6.0	7.2	1.95	1.51
U. S. total	1,605,000	15,459,000	9.6	8.6	$2.48	$1.56

use of barnyard manure is not economical on most oat lands because of the danger of the crop falling, owing to its growing too rank. The same danger is encountered when commercial fertilizer containing nitrogen is applied. Where fertilizers are used for oats, heavily phosphate brands should be used to help hasten ripening, increase grain production, and possibly stiffen straw. The response of the oat crop to applications of fertilizers is not so great as that of other crops, particularly wheat.

FIG. 251. The wild oat, a bad weed in the hard spring-wheat region. Compare with Fig. 252. (Farmers' Bulletin 833).

Seedbed preparation. Oats seem able to produce a crop not only under impoverished soil conditions, but with as little seedbed preparation as any of our important crops. The seedbed which is carefully and thoroughly prepared by breaking and working down does not produce an increase in the yield sufficient to pay for the extra labor involved. This is especially true when the land must be spring-prepared. Fall breaking will usually be more effective than spring breaking.

As a rule, oats follow corn in the rotation, and under such a system fall plowing is not feasible. Yields that are practically the equal of those secured on the plowed lands may usually be expected on the corn-stubble lands, which are prepared by thorough disking early in the spring. Where abundant rainfall is secured, a disc-prepared seedbed is as satisfactory as one more carefully prepared. When the rainfall happens to be low, fall-plowed land, because of its greater moisture-holding capacity, will probably be best. Spring breaking does not prove to be the most economical method, when the methods are compared for a series of years.

Seed and seeding. One factor which is frequently overlooked in the production of oats, is the seed. There is a great amount of variation between different varieties as regards their time of maturity, producing power, etc. Only seed of an adapted variety should be used, and this only after having been fanned and graded thoroughly and treated for smut (Chapter 33.)

The size of the grain of oats has very little, if any, correlation to yield; but heavy, plump seeds are essential, if maximum yields are sought. Small, shriveled seeds which have loose hulls and are light in weight will neither produce as many plants per acre nor yield as well as a crop grown from plump, heavy seeds,

FIG. 252. Typical head of Kherson oats (Neb. Bulletin 82).

even though the number of plants on a given area may be the same.

Market classes and grades. No Federal grades for oats have yet been promulgated in the United States; consequently, each state has its own grades and its own rules for interpreting these. In general, however, the grades in the various states are very much the same, running about as follows:

White oats . .	grades	1, 2, Standard, 3, 4
Red oats . . .	"	1, 2, 3, 4
Mixed oats . .	"	1, 2, 3, 4
White clipped oats	"	1, 2, 3, 4
Mixed clipped oats	"	1, 2, 3, 4

The grades for White oats are interpreted as follows:

No. 1 White oats shall be white, dry, sweet, sound, bright, clean, free from other grain, and weigh not less than 32 pounds to the measured bushel.

No. 2 White oats shall be 96 per cent white, dry, sweet, shall contain not more than 1 per cent of dirt and 1 per cent of other grain, and shall weigh not less than 29 pounds to the measured bushel.

Standard White oats shall be 92 per cent white, dry, sweet; shall not contain more than 2 per cent of dirt and 2 per cent of other grain, and shall weigh not less than 28 pounds to the measured bushel.

No. 3 White oats shall be sweet, 90 per cent white; shall not contain more than 3 per cent of dirt and 5 per cent of other grain; and shall weigh not less than 24 pounds to the measured bushel.

WORLD'S PRODUCTION OF OATS, 1914

LEADING COUNTRIES	ACREAGE	PRODUCTION (bushels)	PER CENT OF WORLD'S PRODUCTION
Russia	46,571,000	883,681,000	21.87
United States . .	38,442,000	1,141,060,000	28.25
Germany . . .	10,843,000	622,674,000	15.43
Canada	10,061,000	313,078,000	7.75
France	8,873,000	274,458,000	6.80
Austria-Hungary .	....	225,651,000	5.59
United Kingdom .	3,879,000	140,241,000	4.46
Argentina . . .	3,087,000	50,981,000	1.26
World's total . .	....	4,034,857,000	....

UNITED STATES OAT PRODUCTION, 1916

LEADING STATES	ACREAGE	PRODUCTION (bushels)	AVERAGE YIELD PER BUSHEL		AVERAGE FARM PRICE PER BUSHEL	
			(1916)	(1907–16)	(1916)	(1907–16)
Iowa . . .	5,050,000	186,850,000	37.0	32.8	$ .48	$ .36
Illinois . . .	4,470,000	172,095,000	38.5	33.1	.51	.40
Minnesota . .	3,325,000	88,112,000	26.5	30.8	.47	.37
North Dakota .	2,500,000	53,570,000	21.5	26.7	.44	.35
Nebraska . .	2,259,000	79,875,000	35.5	26.0	.47	.37
Wisconsin . .	2,200,000	81,400,000	37.0	32.2	.51	.41
South Dakota .	1,850,000	56,425,000	30.5	26.8	.46	.36
Indiana . . .	1,750,000	52,500,000	30.0	29.6	.51	.40
Ohio	1,717,000	48,076,000	28.0	32.5	.53	.42
Kansas . . .	1,550,000	36,425,000	23.5	24.8	.55	.42
U. S. . . .	41,539,000	1,251,992,000	30.1	29.9	$ .52	$ .41

No. 4 White oats shall be 90 per cent white, may be damp, damaged, musty, or very dirty.

RICE. A true cereal, of the grass family, with a comparatively small, fibrous root system and 5 to 25 stems or culms from 24 to 60 inches in height. The grain is one of the world's most important foods; the straw, though little used, is said to be equal in value to good southern prairie hay; and the hulls, chaff, etc., if carefully used with other feeds, are good for stock. Being naturally a marsh plant, rice needs plenty of water and is generally irrigated, except the so-called, not very important, upland type. It is best to grow and plow under a leguminous crop before rice, and to keep down weeds with an occasional cultivated crop, but such rotation is not yet common.

Where grown. Rice is grown in all tropical and subtropical countries and to a small extent in warm sections of some temperate lands. The accompanying table indicates the 4 rice districts in the United States; namely, the small Carolina section, the Texas-Louisiana district of large-scale production, where the irrigation is mainly from wells and bayous, the similar but cooler Arkansas district, and the more recent California district of the Sacramento Valley.

Soils, fertilizers. The best soil is a clay loam with a water-holding subsoil; even a heavy, stiff clay is better than a porous, sandy type. If irrigated, rice can stand considerable alkali. Knowledge as to fertilizer requirements is incomplete; the grain removes only about three tenths of the total nitrogen, phosphoric acid, and potash in the plant, so if the stubble is plowed under, and especially if the land is subject to overflow, there is not much soil depletion. Yields range from less than 10 barrels to 30 barrels (162 pounds each) per acre of cleaned rice. A bushel of rough rice or paddy weighs 45 pounds.

FIG. 253. Heads of Louisiana rice

How grown. In Asia and sometimes in this country, the land is flooded, then harrowed, and the seed sown under water; more often it is plowed and fitted while dry, fall plowing being done where winter rains occur. Seeding is done from March 15 to May 15 at the rate of 1 to 3 bushels per acre, according to locality, variety, etc. A drill should, if possible, be used, covering the seed not more than 2 inches. The growing season is 5 to 6 months; there is no cultivation (except sometimes hand weeding); and irrigation practices differ widely, from continuous flooding during the entire season to none at all. The total water required (irrigation and rainfall) averages half an inch per day for about 90 days. If water is applied to germinate the seed, it must be temporarily drawn off after a few days, to prevent rotting; otherwise it is applied when the crop is a few inches high, and may then remain until the heads droop and the kernels are in the milk. It is usually kept about 6 inches deep, but sometimes as much as 12 for short periods. The depth must be uniform over the field, and the movement sufficient to prevent stagnation.

Harvesting. The grain is harvested when in a stiff dough stage, in some sections with a sickle, and cured before binding; elsewhere with a self-binder, care being taken that the shocked or stacked bundles do not heat too much. Threshing is much like that of other grains. Milling consists of cleaning, hulling, polishing, and grading. *Enemies*: the chief pests are weeds, especially red rice, for which seed must be carefully examined, and barnyard or water grass, often brought in by irrigating, which must be pulled by hand or cut off below the crown and removed before it seeds; the rice water weevil, controlled by drying or alternately flooding and drying the field; the rice or reed bird, which

WORLD RICE PRODUCTION, 1914

COUNTRIES	ACREAGE	PRODUCTION IN POUNDS
India	74,101,000	63,805,168,000†
Japanese Empire	10,933,000	19,866,797,000
Java, Madura	5,860,000	7,187,270,000
Philippine Is.	2,666,000	717,441,000
Ceylon	801,000	457,483,000
United States*	723,000	695,944,000
Asiatic Russia	491,000	276,938,000
Italy	360,000	598,100,000

*1915 figures. †Incomplete report.

RICE PRODUCTION, UNITED STATES, 1915

STATE	ACREAGE	PRODUCTION (POUNDS)	VALUE (DOLLARS)	PER ACRE	
				YIELD	VALUE
Louisiana	401,000	13,714,000	12,343,000	34.2lbs	$30.78
Texas	260,000	7,930,000	7,058,000	30.5	27.14
Arkansas	100,000	4,840,000	4,598,000	48.4	45.98
California	34,000	2,268,000	2,041,000	66.7	60.03
South Carolina	3,700	90,000	81,000	24.3	21.87
Six others	3,900	99,000	91,000	29.2	25.52

may take a tax of 4 bushels per acre; and straight head and rice blast or rotten neck, two diseases for which no effective cure is known.

There are thousands of *varieties* of rice, but only 5 main *types*— two wild, a glutinous form not grown here, a small-kerneled sort including 3 of the varieties grown in the United States, and large-kerneled rice, which includes all the rest.

RYE. Rye is another annual cereal with both winter and spring types and occupying a very important place in the agriculture of many of the great grain-producing regions of the world. This is particularly true in Russia, Germany, and Austria, where black or rye bread forms a large percentage of the bread ration of the people. In America rye is of minor importance as a grain crop, but is largely grown as a winter cover or green manure crop.

As a crop rye does not seem to be as old as wheat; none of it has been found in the ancient tombs, and it is not recorded as a field crop or food in the very early writings as is wheat. The history of rye, therefore, should be more complete, but as a matter of fact very little positive information regarding its origin and early history is available. Some question exists as to the place of origin, but it is thought that rye originated in northeastern Europe.

FIG. 254. The first 3 steps in making a good shock of grain. Set the bundles down firmly and brace well, working from opposite sides. (This and Fig. 255 from "Power Farming")

Adaptation. Rye is a crop adapted to a wide range of climatic conditions and will be found growing under a wider variety of conditions than almost any other cereal. It will endure more cold weather and will ripen with less heat units than wheat; consequently, it is found growing farther north. Rye will also withstand heat, and it will be found growing almost anywhere where wheat can exist, even under warm conditions.

Rye is not only very flexible as regards its climatic adaptation, but is quite as widely adapted to varying degrees of soil fertility. On good soils which are capable of producing heavy yields of corn, and on which wheat and oats would probably lodge because of excessive nitrogen, rye will probably make a very rank growth with a fair seed yield and still not fall. On the other hand, on lands which are badly washed, have been cropped too heavily, or are naturally low in fertility, rye will more nearly make a satisfactory yield than any other cereal that is available.

Because of this tendency to produce a good crop, even on depleted soils, fields which are fertile are usually reserved for wheat or other cereals. Despite this fact, rye is gaining in importance and will doubtless continue to improve in general favor. Even when grown under very unfavorable conditions, it yields practically as much seed, gives better winter pasture, and is a much surer crop than either wheat or barley. Notwithstanding these facts there are certain conditions under which it thrives best. Naturally adapted to a cool climate, and demanding a very large amount of water, rye does best in the cool, moist regions of America, Europe, and Asia. It is best adapted to moderately fertile, well-tilled soils, and, when seeded on very poor, run-down soils, it responds readily to commercial fertilizer or barnyard manure.

Uses. Rye, as a farm crop, is gaining in importance in the United States, at a slow but substantially steady rate. This gain is perhaps due to the several uses for which the crop can be grown. As a grain-producing crop, rye does not rank as high as wheat, although its acre production is practically as good on most soils. When grown as a green manuring or pasture plant, rye has perhaps no superior among the cereals. Rye is sown also for pasture purposes, and as such makes an excellent green succulent food for winter pasturage.

In many regions where wheat is not a successful crop because of climatic or soil conditions, rye is substituted in the rotation and is used as the nurse crop for clover. As a nurse crop, rye is quite satisfactory, as it usually covers the ground well, giving protection in late

FIG. 255. The last 3 steps in making a shock. Spread the capping bundles so they will shed rain and not blow off. The finished shock should be able to support a man.

winter and early spring; and, since it does not stool much and does not create a very dense shade, it gives the young clover a chance to get plenty of sunlight.

Production. This crop, like wheat or any other farm crop, makes its best yields when put on a fertile soil and in a seedbed which has been properly prepared. Despite the known needs of the crop and the advantages of proper seedbed preparation and seeding, rye, as a general rule, receives very poor cultural attention. The best crops of rye may be expected where the seedbed is properly prepared. This should be done as in preparing land for wheat. Prepare the seedbed as early as possible, firm it down well, and keep a mellow, loose surface bed for the seed to go in. A well-prepared seedbed is just as profitable for rye as for wheat.

Rye is frequently seeded broadcast on the surface and harrowed in, like oats; but this is a wasteful practice, as it requires more seed and does not produce maximum yields. Rye, to be properly seeded, should be put in with a grain drill at a uniform depth and should be evenly distributed at the rate of 5 to 8 pecks per acre.

Harvesting and handling. The grain crop of rye is handled like wheat. The cutting is done with the self-binder, and the bound grain shocked and allowed to stand in the field until dry, when it is threshed with the regular wheat thresher. Very little rye is put in stacks, as it is very heavily bearded and is inclined to shatter badly if handled. Another reason is that rye dries out more quickly, is less affected by rains, and its grain does not discolor so readily as that of wheat.

When rye is grown for a pasture and green manure crop, it is not allowed to go to maturity in the spring, but is plowed under early before it has used too much of the moisture. Where the crop is heavy and rank and cannot be plowed under until it gets 2 or 3 feet high, it should be dug down or cut with a mower, and disked into the ground.

Market classes. On the markets but one class is recognized by the trade. The grades for this are Nos. 1, 2, 3, and 4. The seed quality varies from bright, dry, well-cleaned, sweet, plump seed weighing 56 pounds, to musty, shrunken, light seed.

WHEAT. Wheat is one of the oldest of our farm crops. In fact, it has been a very important economic farm product as far back as recorded history is available. Even as early as 3,000 B. C., this crop was a very important one, and was recognized as holding a most prominent place in agriculture. Wheat was doubtless cultivated long before the beginning of recorded history. Its age and the variety of names under which it was recorded make an exact determination of its early history and origin very difficult. Botanists have never been able to agree completely as to the origin of this important cereal. The crop is a native of Europe, probably originating in some

WORLD'S RYE PRODUCTION, 1914

LEADING COUNTRIES	ACREAGE	PRODUCTION IN BUSHELS	PER CENT OF WORLD'S PRODUCTION
Russia	70,892,000	858,185,000	53.73
Germany	15,565,000	410,478,000	25.70
Austria-Hungary	....	119,547,000	7.48
United States	2,541,000	42,779,000	2.60
France	2,614,000	32,002,000	1.37
World's total	....	1,596,882,000	100

RYE PRODUCTION IN UNITED STATES, 1916

LEADING STATES	ACREAGE	PRODUCTION IN BUSHELS	AVERAGE YIELD PER ACRE		AVERAGE FARM PRICE PER BUSHEL	
			(1916)	(1907–16)	(1916)	(1907–16)
Wisconsin	375,000	6,075,000	16.2	17.3	$1.32	$ .79
North Dakota	350,000	4,655,000	13.3	15.5	1.25	.70
Minnesota	335,000	5,025,000	15.0	18.7	1.27	.73
Michigan	325,000	4,648,000	14.3	14.9	1.30	.80
Pennsylvania	260,000	4,420,000	17.0	16.9	1.09	.81
South Dakota	250,000	4,500,000	18.0	16.6	1.18	.69
Nebraska	192,000	3,072,000	16.0	15.8	1.16	.69
Indiana	185,000	2,590,000	14.0	15.4	1.19	.78
New York	151,000	2,718,000	18.0	17.3	1.28	.87
Ohio	75,000	1,088,000	14.5	16.4	1.20	.81
U. S.	3,096,000	47,383,000	15.3	16.3	$1.22	$ .79

of the eastern Mediterranean countries. So far as known, no evidence is available of the crop having been grown in America until after Columbus discovered the continent.

Kinds of wheat. Because of its age and the consequent wide distribution of the wheat crop over the world, there are now 8 more or less distinct and rather easily distinguished species and subspecies. These species or types are here given together with their botanical names and the names of countries where grown:

(1) *Triticum monococcum*, Einkorn, Europe.
(2) *Triticum sativum spelta*, Spelt, Europe.
(3) *Triticum sativum dicoccum*, Emmer, Europe and Northwestern United States.
(4) *Triticum sativum vulgare*, Common Wheat, United States.
(5) *Triticum sativum compactum*, Club Wheat, Northwestern United States.
(6) *Triticum sativum turgidum*, Poulard, Mediterranean.
(7) *Triticum sativum durum*, Durum, Semi-arid West United States.
(8) *Triticum polonicum*, Polish, Mediterranean.

There are really but 3 decidedly distinct types. Einkorn, Polish, and common. The latter class includes the others mentioned, such as the Club, Durum, etc. Except for the Spelt and Emmer the types of this group are very similar. Of all the types mentioned, the Common, Club, Durum and Emmer are the most important as sources of human food. Common and Club wheats are much more important than the others for flour, bread, and pastures.

Common wheat, the important type of America, is distributed quite generally throughout the United States. Because of this wide soil and climatic distribution, many varieties and regional types have been produced. There are 8 more or less distinct wheat areas in the United States, each bearing the name of the wheat it produces. The most important regions are the following: Semi-hard wheat district including the states east of the Mississippi River, and parts of Missouri, Iowa, Arkansas, and Texas; Hard Winter wheat district including Kansas, Nebraska, Oklahoma, and parts of Iowa and Missouri; Hard Spring wheat district including the Dakotas, Minnesota, parts of Wisconsin, Iowa, Nebraska, and Montana; Soft Wheat district including the states lying west of the Hard Winter and Hard Spring sections; Durum district, which lies to the west of the hard wheat districts and is in the semi-arid section of the country. The soft wheat, which is largely produced in the Pacific Northwest, is mainly a spring wheat, although some winter wheat is grown in the district.

As a result of continued study and experimentation, each wheat district is found to have one or more varieties of wheat which seem particularly well adapted to the section. The semi-hard wheat district has a great number of varieties commonly grown, but the more important are Fultz, Poole, Dawson's Golden Chaff, Fulcaster, Mediterranean, and Rudy. This wheat is a medium hard, rather starchy berry.

The hard winter wheat district has perhaps a smaller number of varieties, and the tendency is more and more to select only one or two of the best. Turkey and Karkov are the two most common ones.

Varieties of hard spring wheats are not found in great abundance, and the Fife, Blue Stem and Velvet Chaff are the three most commonly grown.

The soft wheat district of the Northwest has several varieties and yet not as many as the semi-hard district. The best varieties are California Club, Washington Club, Oregon Red Chaff, Little Club, etc. Durum wheats in that section are largely of the Kubanka variety. The Arnautka is another variety which is grown over a considerable acreage.

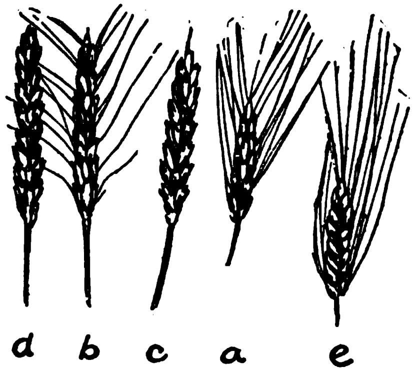


FIG. 256. Popular strains of wheat: *a* Fife; *b* Velvet chaff; *c* Blue stem; *d* Turkey red; *e* Durum (Wis. Bulletin 233.)

Adaptation. Wheat may be said to be almost universally grown, and yet its adaptation for successful production is practically restricted to the Temperate Zone. In general, wheat may be said to be adapted to temperate regions where the winters are cool or cold and the summers moderate.

Wheat, to make its best development and yield of grains, demands a cool, moist season for its early growth and a warm, rather dry ripening period. The same wide adaptability as regards soil requirements is noted. Wheat is found growing on the very poorest, and in other places on the very richest, soils. The best wheat soil is not the rich one, nor is it the very poor one, but the soil of medium fertility. To do its best, wheat needs an ample supply of nitrogen, a large amount of phosphorus, and a moderate amount of potash.

Seedbed preparation. Wheat is a crop

which, despite the fact that it is not generally so cared for, demands, for successful production, just as thorough seedbed preparation as it is possible to give. The most successful wheat farmers practise early and thorough preparation of the seedbed. For fall-sown or winter wheat the land is disked and broken deeply early in the summer, harrowed and rolled down immediately, and then kept harrowed at intervals of a week or 10 days throughout the remainder of the time until seeded. In the fall-wheat section, where wheat follows corn, it can best be seeded after cutting the corn and seeding in the seedbed prepared by disking the corn stubble. Another method consists of seeding the wheat

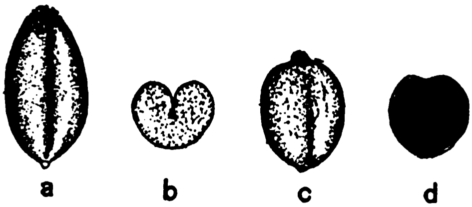


FIG. 257. Healthy, plump wheat kernels, entire (*a*) and in cross section (*b*) as contrasted with "smut balls" or grains infested with smut spores (*c* and *d*).

in between the corn rows before the corn has been gathered. This latter method is not so successful as either of the other 2, because of the poor seeding and the fact that much ground is not utilized where the stalks remain standing.

In the spring-wheat district many experiments and the experience of the best farmers have shown that the best spring-wheat crops can be produced on fall-plowed land. The fall plowing permits early preparation of the seedbed and early seeding, which latter is a most essential factor in spring-wheat production. Fall preparation also has the advantage of helping to store additional moisture which is badly needed in the drier parts of the spring-wheat district.

Not all the spring wheat is seeded on fall-plowed land, but some must be sown on land which is spring-prepared. Such lands are usually disked and plowed and the wheat sown just as rapidly as possible. In some places, particularly on stubble lands, wheat is sown in land that has simply been double-disked. Like all other short cuts to successful farming, this method does not produce maximum yields.

Wheat fertilizers. A good grade of barnyard manure, either turned under or top-dressed, is the most widely used and perhaps the most economical fertilizer available for wheat. Where manure is not available, commercial fertilizers are coming to be more generally used. On most wheat soils a fertilizer containing a high percentage of phosphorus is the most economical to buy. The amount of the other constituents, nitrogen and potash, is determined largely by the type of farming and the availability and price of the fertilizer. In general, nitrogen can be more economically supplied in legumes than by the addition of commercial fertilizers. The potash content of most fertilizers need not exceed 2 or 3 per cent, even on lands low in this element. Such lands constitute a very small percentage of the winter- and spring-wheat districts of the United States. Phosphates are by far the most important wheat fertilizers needed.

Seeding. The importance of adapted varieties and pure seed is coming to be recognized as increasingly important. Along with this realization of the importance of pure seed has come the recognized necessity of sowing only clean, plump seed of known high vitality. The importance of the wheat fan to grade out the small, shriveled kernels of weak vitality is quite generally recognized.

In the spring-wheat section, the date of seeding varies with seasonal conditions, but in general it is done during the month of April. In the winter-wheat area the time of seeding varies from September 10 to October 20. If fall seeding is done too early, the plant makes too great a growth and, thereby, becomes less hardy to withstand the cold winters; late seeding may not permit the young plants to get well started and become thoroughly rooted before winter. This condition, also, is conducive to a large per cent of winter-killing.

WORLD'S PRODUCTION OF WHEAT, 1914

LEADING COUNTRIES	ACREAGE	PRODUCTION IN BUSHELS	PER CENT OF WORLD'S PRODUCTION
United States .	53,541,000	891,017,000	24.85
Russia . . .	75,369,000	751,835,000	20.96
India . . .	28,475,000	312,032,000	8.70
France . . .	14,975,000	282,689,000	7.88
Italy	11,783,000	169,581,000	4.72
Austria-Hungary	......	153,477,000	4.27
Germany . .	4,932,000	145,944,000	4.06
Spain . . .	9,681,000	116,089,000	3.23
Argentina . .	16,243,000	113,904,000	3.17
Australia. . .	9,453,000	112,159,000	3.12
World's total .	....	3,585,916,000	100

The amount of seed varies with the variety, the soil, and climatic conditions. In general, 4 to 6 pecks per acre is the proper rate. If less than 4 pecks are seeded, unfavorable seasonal conditions or a severe winter may cause the subsequent stand to be so thin that the maximum yield cannot be secured. Thin stands may even permit weed growths to come in to the extent of materially decreasing the quality of wheat produced.

Harvesting. The harvesting of the wheat crop in the semi-hard, hard winter, and hard spring wheat districts is almost universally done with the self-binder. In the soft-wheat districts, particularly in the Pacific Northwest, the combined harvester and thresher is quite generally used.

Where the self-binder is used, the wheat is cut when it is turning yellow or golden, and is shocked or stacked in the fields to await the arrival of the thresher. Where the wheat is shocked, the threshing should be done in from 2 to 4 weeks after cutting, or just as soon as the wheat has gone through the sweat or the curing-out process. Wheat which is stacked, however, may be left until late summer without injury. A properly built stack of wheat will not admit water, and the wheat threshed from such stacks will be in perfect condition even though it may not be threshed for 2 or 3 months after cutting.

Market classes and grades. The federal grade standards for wheat, which are used in all markets of the country, recognize the following classes and subclasses: (1) Hard Red Spring, including Dark Northern Spring, Northern Spring, Red Spring, and Red Spring Humpback; (2) Common and Red Durum, including Amber Durum, Durum, and Red Durum; (3) Hard Red Winter, including Dark Hard Winter, Hard Winter, and Yellow

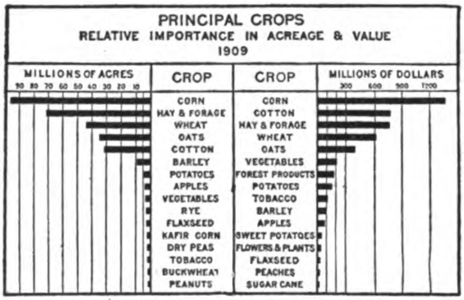


FIG. 258. Compare this chart with maps on pp. 208 and 209 and with the maps farther on in this chapter showing the distribution of important crops. (1915 Yearbook, U. S. Dept. of Agr.)

Hard Winter; (4) Soft Red Winter, including Red Winter, Red Walla, and Soft Red; (5) Common White, including Hard White and Soft White; (6) White Club. Each of these has the following grades: No. 1, No. 2, No. 3, No. 4, No. 5, and Sample.

Wheat statistics. The average yield in the United States is 13.2 bushels per acre for spring wheat and 15.6 for winter wheat; 30 to 40 bushels are not uncommon; and 60 bushels or more occur under ideal conditions.

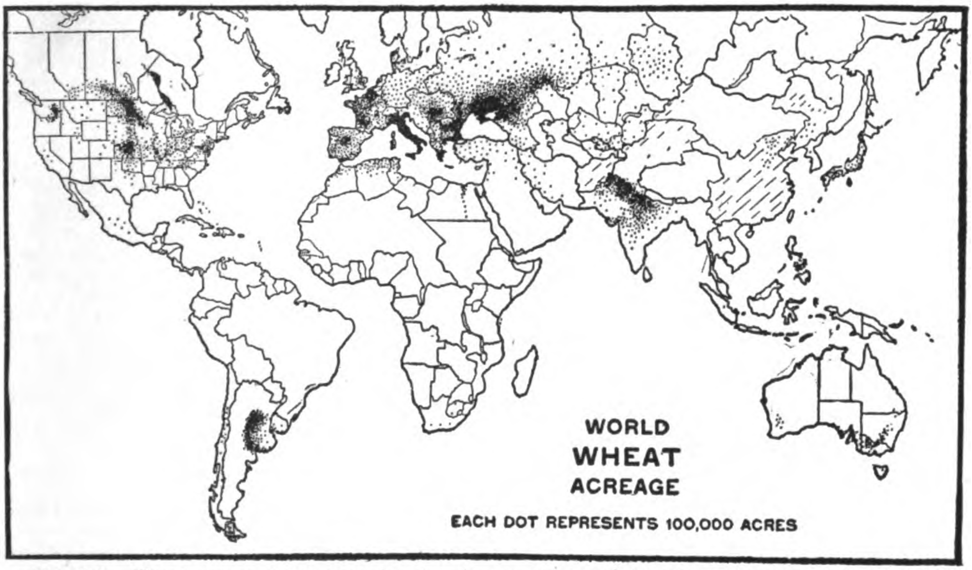


FIG. 259. Wheat, the most important bread grain, was also one of the most widely grown before the World War. Demoralized conditions in Europe in 1917 threw heavy responsibility on American wheat growers. (1916 Yearbook, U. S. Dept. of Agr.)

UNITED STATES WHEAT PRODUCTION, 1916

Winter Wheat

LEADING STATES	ACREAGE	PRODUCTION IN BUSHELS	AVERAGE YIELD PER ACRE		AVERAGE FARM PRICE PER BUSHEL	
			(1916)	(1907–16)	(1916)	(1907–16)
Kansas	8,130,000	97,560,000	12.0	13.6	$1.64	$ .94
Nebraska	3,240,000	64,800,000	20.0	18.1	1.60	.90
Oklahoma	3,050,000	29,585,000	9.7	12.1	1.67	.96
Missouri	1,950,000	16,575,000	8.5	13.5	1.65	.99
Indiana	1,620,000	19,440,000	12.0	15.0	1.69	1.03
Ohio	1,500,000	20,250,000	13.5	15.9	1.69	1.05
Illinois	1,475,000	16,225,000	11.0	15.5	1.65	1.00
Pennsylvania	1,375,000	26,125,000	19.0	17.6	1.62	1.04
Virginia	1,300,000	16,250,000	12.5	12.6	1.65	1.08
Texas	1,200,000	13,200,000	11.0	12.4	1.73	1.08
U. S. total	34,829,000	481,744,000	12.9	14.6	$1.65	$1.00

Spring Wheat

LEADING STATES	ACREAGE	PRODUCTION IN BUSHELS	AVERAGE YIELD PER ACRE (1916)	AVERAGE YIELD PER ACRE (1907–16)	AVERAGE FARM PRICE PER BUSHEL (1916)	AVERAGE FARM PRICE PER BUSHEL (1907–16)
North Dakota	**7,150,000**	**39,325,000**	**5.5**	**11.2**	**$1.52**	**$ .93**
Minnesota	**3,650,000**	**26,645,000**	**7.3**	**13.5**	**1.62**	**.97**
South Dakota	**3,500,000**	**22,050,000**	**6.3**	**11.0**	**1.50**	**.92**
Montana	**935,000**	**16,830,000**	**18.0**	**23.5**	**1.61**	**.88**
Washington	**900,000**	**19,350,000**	**21.0**	**19.7**	**1.43**	**.86**
Iowa	**320,000**	**4,160,000**	**13.0**	**15.5**	**1.56**	**.93**
Nebraska	**300,000**	**3,750,000**	**12.5**	**12.9**	**1.60**	**.90**
Idaho	**290,000**	**6,815,000**	**23.5**	**25.6**	**1.46**	**.81**
Oregon	**270,000**	**6,210,000**	**23.0**	**23.3**	**1.45**	**.89**
Colorado	**230,000**	**4,485,000**	**19.5**	**22.9**	**1.50**	**.89**
U. S. total	**17,956,000**	**158,142,000**	**14.9**	**17.9**	**$1.52**	**$ .89**
U. S. grand total	**52,785,000**	**639,886,000**	**12.1**	**14.7**	**$1.60**	**$ .96**

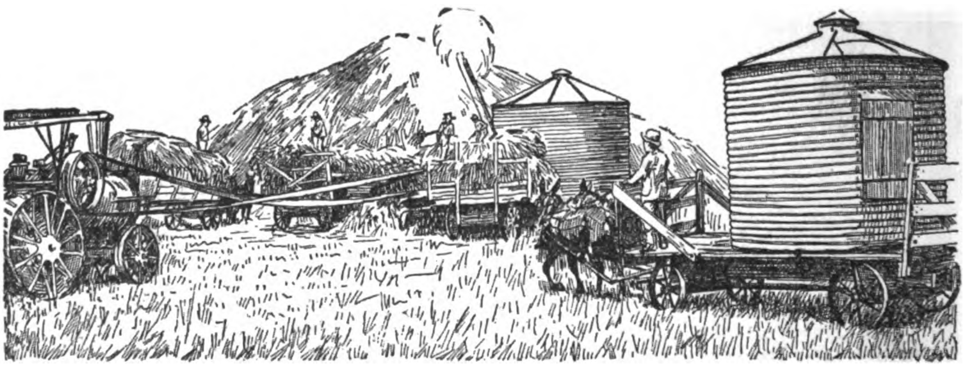
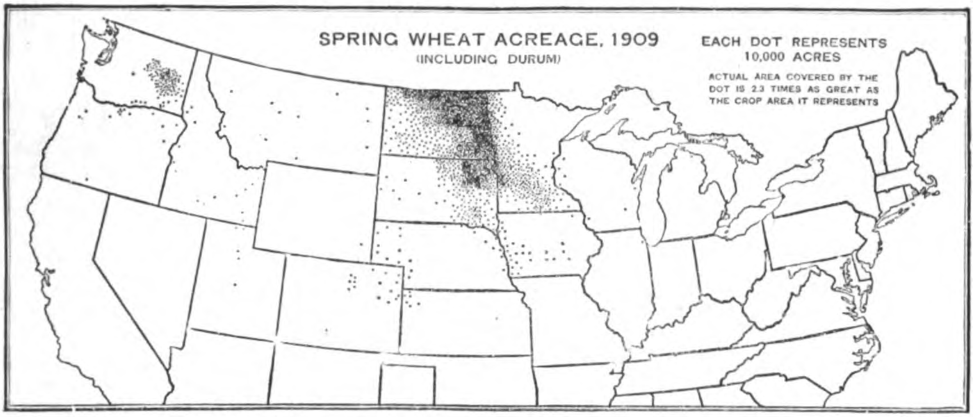
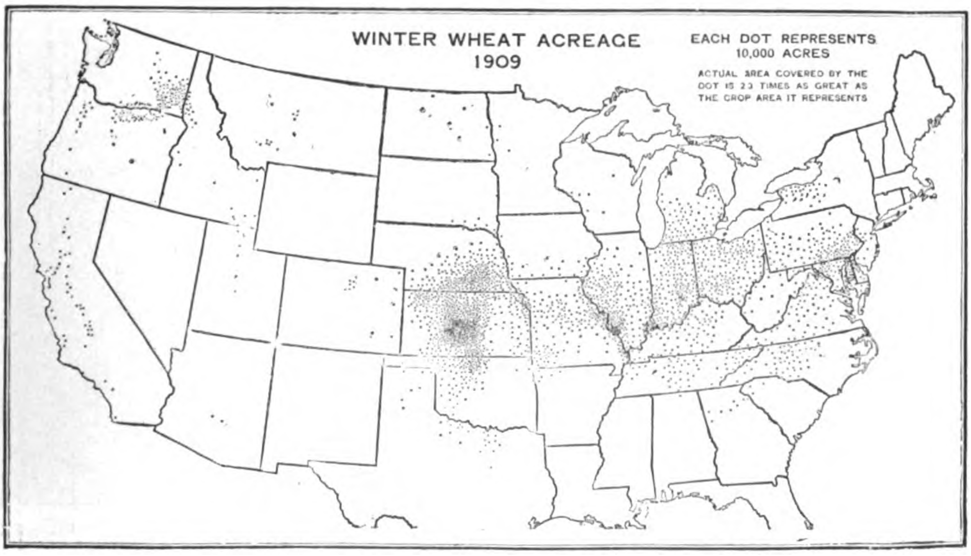


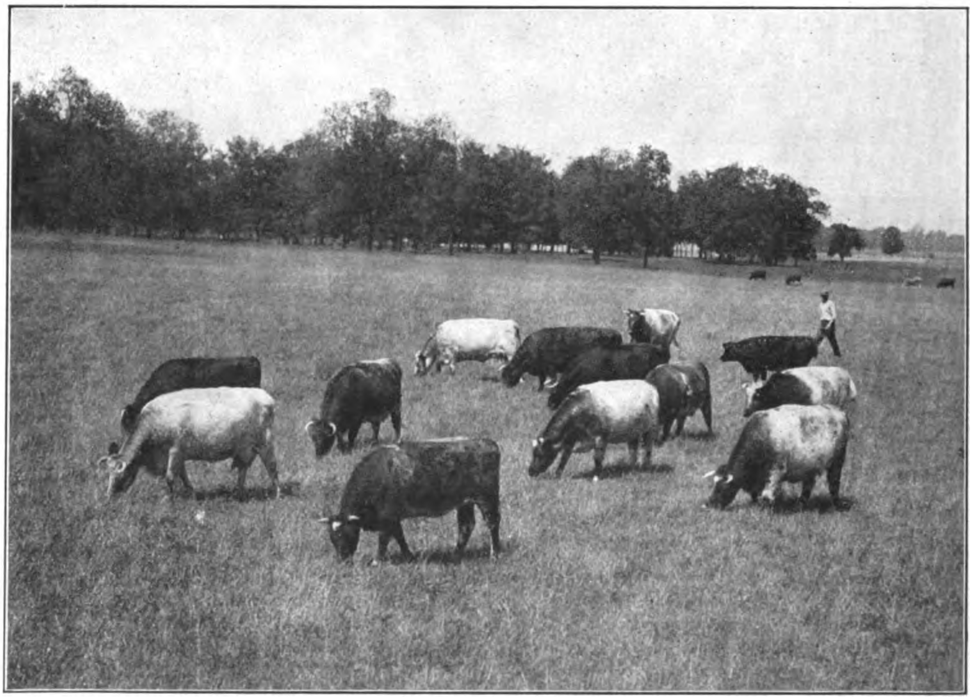
Fig. 260. Portable metal granaries are a great convenience when an extra large crop makes it desirable to save time and hauling and therefore to store the grain temporarily in the field





Wheat was Raised when the World was Young; To-day it is Man's Greatest Bread Grain. Upon it has Always Hung the Fortunes of War and the Fate of Nations

Too much land in the United States is growing poor hay crops. It is only such fields as this that keep the average yield per acre at about a ton and a half



In the minds of all who know it, blue-grass pasture is synonymous with the finest of cattle and horseflesh

THERE ARE GRASSES FOR ALL CONDITIONS AND PURPOSES; THE PROBLEM IS TO CHOOSE THE RIGHT ONES

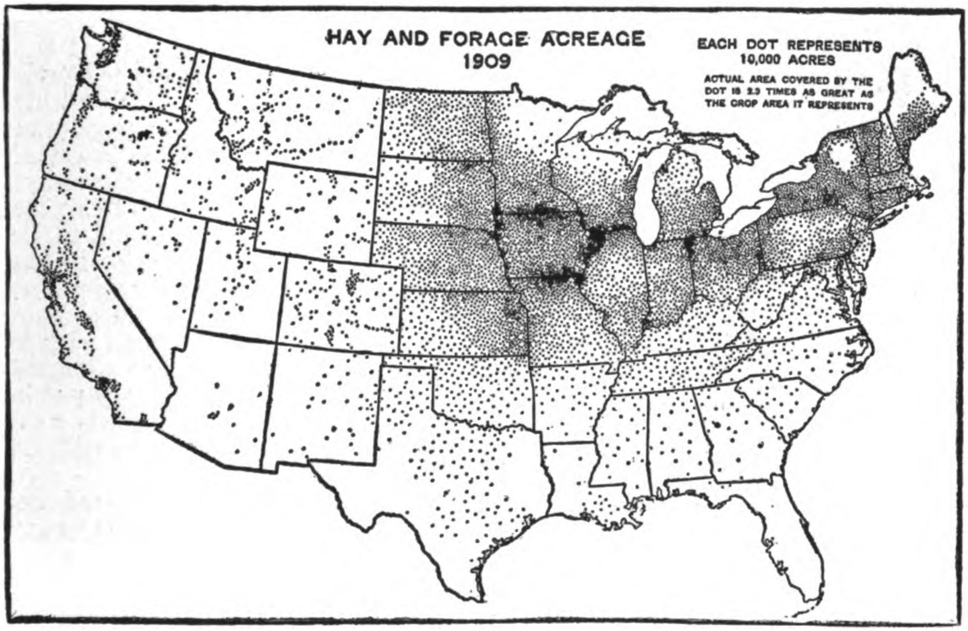


FIG. 261. Among the important changes that have taken place, since this map was made, is the greatly increased acreage of forage crops in the South. The more forage crops, the more livestock, and the more soil fertility. (1915 Yearbook, U. S. Dept. of Agr.)

C. FORAGE CROPS: OTHER THAN LEGUMES

By H. D. HUGHES, *Professor of Farm Crops, Iowa State College and Chief in Farm Crops, Iowa Agricultural Experiment Station. He was born and lived for 20 years on a northern Illinois farm and later gained additional farm experience in central and southern Illinois, Missouri, Iowa, and South Dakota. Before taking up his present work, he was connected with the Missouri Agricultural College and Experiment Station, and superintended the production of crops on the College Farm there. Although all forage crops are grown with the same object in view—the feeding of animals—they fall into 2 main groups on the basis of important structural differences. Thus there are discussed here the grass and grain plants which are grown either as pasture or to be fed green or cured as hay; the next section treats the other group—the legumes, many of which have the same threefold field of usefulness. In actual farm practice, of course, crops from both groups can be and often are combined giving, indeed, one of the most effective means for making land fruitful and keeping it productive.*—EDITOR.

IT IS estimated that 30 per cent of the improved land in the United States is in grass or grass mixtures, having an annual value exceeding that of any other crop. This includes both pastures and meadows.

Meadows. Timothy (p. 245), orchard-grass (p. 247), brome-grass (p. 248), and red-top (p. 247) are the principal hay grasses. A timothy and clover mixture is a combination used very extensively. Other mixtures are: timothy and brome-grass, used where clover does not grow; red-top and alsike clover, often sown in the timothy belt on land too wet for timothy and clover; orchard grass, tall-oat grass, and alsike clover, a good mixture in the southern part of the timothy belt.

The time of cutting hay is governed by several factors: (1) it is desirable to get the greatest total yield; (2) hay should be cut when it may be the most easily or the most satisfactorily cured; (3) it should be cut at such a time as will give a

FIG. 262. In dry regions where hay is stacked outdoors, it is hauled to the stacker with horses—

good aftermath; (4) some importance should be placed on the digestibility—hay cut too late being woody and less nutritious. Haymaking in dry regions is a simple process, involving only a wilting in the swath, curing in windrows, and hauling. In humid regions, however, more operations are usually necessary; the hay is often turned, so as to expose the most of it to the sun and wind, either in the swath with a tedder, or in the windrow with a rake. The hay is often allowed to finish curing in the windrow, or is put in cocks when the leaves are dry, but while the stems still contain moisture. The curing process consists of a gradual reduction of the moisture content from approximately 70 per cent down to 15 per cent and also chemical changes, with the development of a characteristic odor or aroma. Hay put in before it is properly cured will heat, and is even in danger of spontaneous combustion, which means heating to the extent that it may burst into flame without being ignited.

Pastures. The principal pasture grasses are Kentucky blue-grass, red-top, and Bermuda grass. The qualifications of a good pasture grass are (1) early growth in the spring; (2) ability to withstand tramping and grazing by forming a tough sod; (3) rapid growth of nutritious and palatable grass, and (4) a late growth in the fall. Often these things can be best met by seeding a mixture of various grasses. Mixtures are advantageous for several reasons: (1) different grasses are adapted to different soils, and so utilize the entire field; (2) seasonal variations are less pronounced in mixtures; (3) a mixture takes advantage of different soil depths since some grasses are deep-rooted, some shallow-rooted; (4) different grasses, at their best at different times of the year, furnish a permanent pasture.

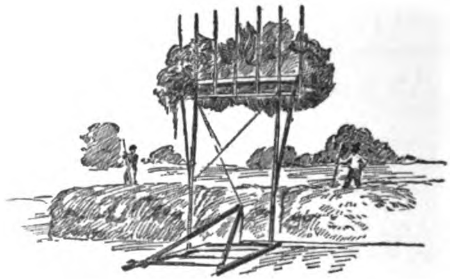


FIG. 263.—Then lifted bodily and thrown on to the stack to be leveled off

Cereals for hay. Any of the cereals may be used for hay, and, as a matter of fact, the acreage of hay from cereals is approximately equal to the acreage of alfalfa. Oat hay, which is superior to timothy in feeding value, is used to a considerable extent in the central and southern states while barley is used in California, and wheat and barley in the northwest Pacific Coast states. The method of growing these crops for hay does not differ from that used in growing them for grain, nor does the handling of the grain-hay crop differ materially, from the handling of any other hay crop. The time of cutting is most important: cut when the heads are in the milk or soft dough stage, before any of the leaves have commenced to dry. If cut sooner, the hay will be less nutritious; if cut later, the hay will be woody and unpalatable. Good oat hay is superior to timothy hay in feeding value.

FIG. 264. Curing in the cock is an important haymaking practice in humid sections

TIMOTHY. Timothy is a perennial grass, ranking first among all the hay grasses grown in this country. It is not native to the New World, but was first brought into cultivation in the United States about 1740. Yet it has not assumed the importance in Europe that it has in America. Practically all the hay grass grown in the northeastern United States and in southern Canada is timothy. The value of the crop (including timothy mixtures) in 1909 was $300,000,000.

Its popularity as a hay plant can be attributed to several advantages it has over other hay crops: (1) it produces good yields of hay for which there is always a good market demand; (2) a stand is easily secured, probably with less labor and at less expense than most other grasses, largely because of the low cost per acre of seeding; moreover, timothy seed

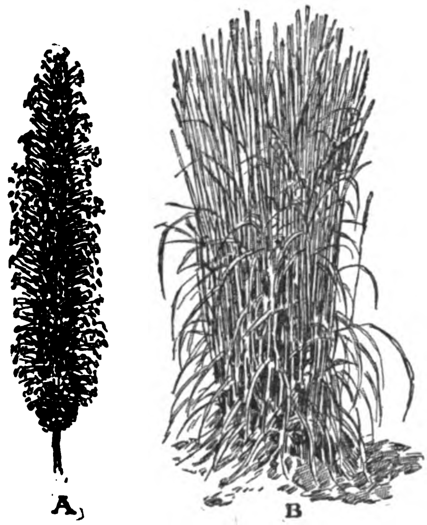


FIG. 265. Timothy. A single head in full bloom (*a*) and a single plant of excellent type (*b*)

usually germinates well, and is high in purity; (3) the crop is easily handled, seldom lodges, can be cut over a long harvest period, and is easily cut and cured. Objections to timothy are (1) its woodiness; (2) its low nutritive value; (3) its lateness, such that in mixtures it must be cut before it is quite ready, and (4) the aftermath is small.

Timothy is primarily a hay plant. Alone, it is not well adapted for permanent pasture. It does not do well south of Tennessee, Missouri, and Kansas because it cannot withstand hot, humid summers, but north of this line it can be successfully grown from the Atlantic to the Pacific. It thrives best on clay or clay loam soils of good fertility. It does not resist drought very well. The greatest yields are often secured on bottom lands where a plentiful supply of moisture is available.

FIG. 266. A brush harrow is an easily made and effective implement for covering grass seed

Timothy is commonly used in rotations in the North. Often it is seeded with clover, when the first year's crop will be timothy and clover, the second year's crop timothy and a little clover, and those coming after, timothy alone. A typical rotation is corn, oats, wheat, clover, timothy. Timothy is sometimes kept down for 5 years or more; where kept down for long periods, seed crops are usually harvested.

The proportion of timothy grown for seed, is, of course, very small compared with that grown for hay either alone or in mixtures. Although differences are known to exist in different timothy plants, no strains or varieties have yet been developed commercially.

How to grow timothy. Very little timothy is seeded alone in the timothy belt, except in the southern part, or where weeds are troublesome. The crop is more often seeded with grain in the fall or spring. Therefore it is unnecessary to discuss the preparation of the seedbed except where timothy is seeded alone. Fall plowing is highly desirable, since it makes for a firmer and finer seedbed which is the most favorable for timothy. Rolling the ground if lumpy or loose is an excellent practice. Good judgment is required to make a good seedbed; the disc harrow, the spike-tooth harrow, and under certain conditions a roller and float, are the implements needed after plowing.

Seeding. Most timothy is seeded in the fall, with wheat or other grain, the seed dropping either before or after the grain drill; if the latter, it should be covered by harrowing. An ordinary seeding is 12 to 15 pounds per acre but if sown with clover the amount is reduced to about 9 pounds. It is claimed by some that many farmers do not cover the seed deep enough.

Another method of seeding, best on weedy ground, is in the fall, alone, on prepared land.

FIG. 267. Except in very small-scale operations, the labor problem makes such methods as these unprofitable, if not impossible.

FIG. 268. Good haying practice involves starting the mowers early while the grass is moist

Grain stubble is plowed and the seedbed well prepared, when the timothy may be seeded in late summer or early fall. With sufficient moisture in the fall, a good crop is secured the next season which will be very free from weeds. Seeding in the spring with a grain nurse crop is the common practice near the northern limits of the timothy belt, where fall grains are not seeded. Clover is often seeded with timothy in this method of seeding, just as in the fall seeding with grains. Practically no crop is secured the first season. Spring seeding without a nurse crop, alone, or with clover, is practised on irrigated lands of the Northwest, and in regions where the soil moisture conditions do not permit a fall seeding. The earliest seedings are the best. The first season's crop is usually small.

Harvesting. For hay, the time to cut is after the blooms have dropped off and the seed has begun to form; however, the crop may be cut over a comparatively long period. If cut with the blooms on, the hay will have the most protein, and will be the most palatable and digestible, but the curing will be more difficult; at a later stage, when the seed is formed, the yield will be greatest, but the hay will be poorer in quality. Timothy cut in the morning of a good day can be raked and hauled in the afternoon, or the morning of the next day. Timothy is quite easily cured and handled, and it pays to use as much machinery as possible.

The average yield of timothy over the United States according to the last census was 1.22 tons. This is quite low, good yields averaging 2 tons per acre, while 3 tons or more are secured on rich land.

For seed, the timothy crop is quite reliable. It is cut when mature, usually with a binder, and allowed to cure for a week or more in the field before threshing. The average yield is

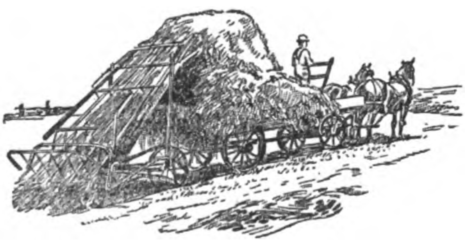


FIG. 269. With a hay loader one or two men can do the work of half a dozen and do it better

about 7 bushels per acre. Most of the timothy seed is produced in Iowa, Illinois, Minnesota and South Dakota.

Market value and grades. The farm price per ton of timothy hay went up from about $12 in 1912 to more than $18 in 1916. A hay crop requires about 18 hours of human labor and 18 hours of horse labor to harvest and stack a ton of the first cutting. Timothy is considered a profitable hay crop, because it requires no extra labor for cultivation or tillage and all of the operations are applied directly on the crop. The market classes of timothy hay and their requirements are as follows:

Choice: Shall be timothy not mixed with more than one twentieth other grasses, properly cured, bright, natural color, sound and well baled.

No. 1: Shall be timothy with not more than one eighth mixed with clover or other tame

FIG. 270. A type of hay barn common and highly successful in the Middle West. The hay loading rigging is a good investment anywhere.

grasses, properly cured, good color, sound and well baled.

No. 2: Shall be timothy not good enough for No. 1, not more than one fourth mixed with clover or other tame grasses, fair color, sound and well baled.

No. 3: Shall include all hay not good enough for other grades, sound and well baled.

KENTUCKY BLUE-GRASS. Kentucky blue-grass, also known as Blue-grass, June grass, Green grass, or Smooth-stalked meadow grass, is a strong perennial, which, unlike most grasses, becomes more productive the longer it grows. It is not native to America, but because of its great value has been distributed widely until now it is the most important pasture grass in this country, and as a hay grass is second in value only to timothy; it is also the most common of the lawn grasses. It is found all over the timothy regions and in a few states south of the timothy belt.

Kentucky blue-grass thrives best on well drained loams or clay loams—the richer the soil the more luxuriant the growth. It grows from 3 inches to 3½ feet in height, depending on the soil and closeness of cropping, but

FIG. 271. Kentucky blue-grass

commonly from 15 to 24 inches; it does not do so well in shade as some other grasses. Its rootstocks or underground runners, by which it spreads itself or thickens, are very numerous, enabling it to crowd out most grasses. It is shallow rooted, and does not withstand drought or hot weather well; in fact, even with abundant moisture, its growth during the hot weather of July and August is small. Its great value lies in its early spring growth, for it is the earliest of grasses; it also grows later than most grasses. It endures cold better than most grasses, and forms a firm, tough sod that stands tramping and grazing well. It is associated with the production of fine horses and the best of grass-fed cattle, large numbers of beeves being fattened practically on blue-grass alone. This type of feeding is most practised in parts of Michigan, Kentucky and the Virginias.

How to grow it. Kentucky blue-grass is seldom sown alone, since it requires 2 or 3 years to make a good sod; it is, therefore, usually seeded in mixtures with other grasses and clovers, which furnish pasture or hay until the blue-grass makes a sod. Prepare the ground thoroughly, as the seed is very small. Ten to 20 pounds of seed per acre are considered right in mixtures, but it is very important to get seed of good vitality, as much worthless blue-grass seed is on the market.

When a blue-grass pasture becomes thin or sod-bound, it is a good practice to disc it up without plowing, and sow a mixture of clover and blue-grass. The clover will furnish pasture while the blue-grass is making a sod.

Harvesting. Blue-grass is too small to give profitable yields of hay, and, therefore, is seldom used for this purpose. It yields, on the average, one ton per acre of hay not quite equal to timothy in feeding value. Harvesting for seed is confined mostly to Kentucky, northern Missouri and southern Iowa. The seed is gathered after the heads turn yellow and the seeds are firm, either by hand strippers or machine strippers, which strip the heads from the stalks. The stripped heads are then carefully cured in piles small enough to prevent heating, and the seed when cured is cleaned by special machinery. Yields average 15 (14-pound) bushels per acre, and the seed sells for from 15 to 20 cents per pound.

REDTOP. Redtop, so called because in midsummer the heads have a reddish-purple color, is a perennial grass, bearing some resemblance to blue-grass. It has a wider range than almost any other grass, succeeding everywhere in the United States except in the extreme South or in the drier regions. It is especially adapted to moist or wet soils, and does best on clay or clay loams. It withstands considerable drought, and is more resistant to heat and cold than timothy. It has a shallow root system with numerous rootstalks or runners, and forms a dense turf. Redtop is most useful in pasture mixtures; it will grow where the soil is too wet or too acid for other grasses of the mixture.

FIG. 272. Redtop

Redtop is rarely sown alone except where grown for seed. Usually only a small amount of seed is included in mixtures, since it spreads rapidly. It may be sown in the same manner as timothy with nurse crops. Hay yields range from 1 ton to 2 or 3 tons per acre. Redtop seed is grown mainly in southern Illinois.

ORCHARD GRASS. Orchard grass, so named because it grows well in the shade, and is therefore grown to a considerable extent in orchards, is a perennial grass with a tufted manner of growth, with rather coarse culms, and which grows to a height of 2 to 4 feet. It is adapted to the temperate climate, but withstands more heat and less cold than timothy. It is cultivated most abundantly just south of the timothy region. It starts much earlier in the spring than most grasses. It succeeds well in shady places, and thrives

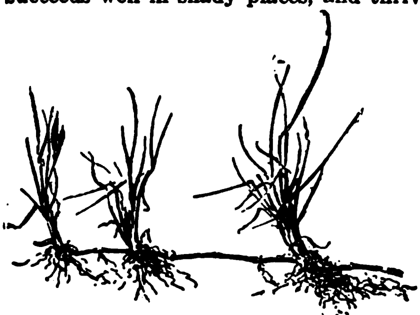


FIG. 273. Showing how blue-grass multiplies and spreads by means of underground stems. (N. Y. [Cornell] Bulletin 280.)

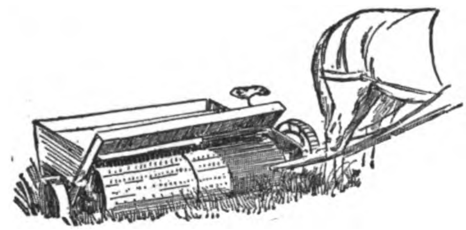


Fig. 274. A machine stripper for harvesting blue-grass seed. The cylinder is studded with pins which brush the seed into the container behind.

best on clays and clay loams. It is not adapted to sand or muck soils. When cut sufficiently early, its yield and feeding value are about equal to those of timothy hay.

Orchard grass may be sown in the fall or early spring, but spring seedings are preferred, because winterkilling is apt to be quite severe. Sow 20 to 25 pounds per acre of good seed on fall wheat or in oats as early in the spring as possible. No crop will be obtained the first year. For seed production, sow 15 to 20 pounds per acre.

Cut orchard grass for hay not later than when in full bloom or the quality will be poor; this will usually be about 3 weeks ahead of timothy. Two cuttings per year are secured under favorable conditions. Most of the seed is grown in Kentucky, Ohio, and Indiana; the average yield is 10 to 12 bushels of 14 pounds each. Orchard grass is most valuable in mixtures, in which case from 8 to 12 pounds are used. It does not fully utilize the ground when seeded alone because of its bunchy growth.

BROME GRASS. Brome grass, known also as smooth brome, awnless brome, Hungarian brome, Austrian brome, and Russian brome, is a long-lived, perennial grass, a native of Europe, and classed among one of the best hay grasses in the United States. Its root system is very deep, with numerous underground runners by which it spreads rapidly and forms a dense sod. It is valuable in regions of rather low rainfall and moderate summer temperatures, and is noted for its ability to withstand drought. It is distributed and most successfully grown in the semi-arid regions of the West, and in the Great Plains area of the Northwest and Canada.

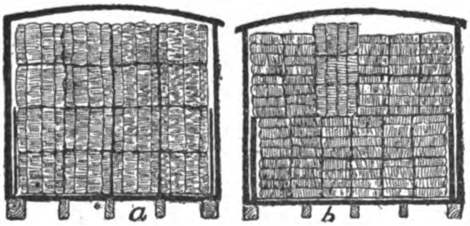


Fig. 275. Two methods of packing hay in a freight car so as to save space and keep the load solid. (Farmers' Bulletin 508.)

It is valuable for both hay and pasture, alone and in mixtures.

How to Grow. Sow brome grass in the spring with a light seeding of a grain crop, on a good seedbed at the rate of 14 pounds per acre; or it may be sown alone in the spring; in either case, fall plowing is preferable to conserve moisture. It makes little growth the first year. It should be cut for hay just after full bloom. Under favorable conditions, 2 cuttings can be obtained. Yields average 1½ tons per acre, but may exceed 3 tons. Brome grass is at its best the third year; after that, it becomes sod-bound, and only a few culms are sent up. To renew its vigor, harrow with the disc, or plow very shallow in the spring; the grass will come on again without seeding. Or plow it in the fall and seed to oats or wheat the next spring; then the following year, a full crop of grass is obtained. Seed production is confined to the Dakotas, and to southern Canada. The crop is usually cut with a binder when the seed is brown and nearly ripe, shocked for curing, and threshed in an ordinary threshing machine. Seed yields are from 200 to 600 pounds.

Fig. 276. Awnless brome grass

CANADA BLUE-GRASS. Canada blue-grass, known also as wire grass, flat-stalked meadow grass, and Virginia blue-grass, like Kentucky blue-grass, is native to the Old World; in America it is distributed over the blue-grass region, but important only in the northern section of the region. It is most important in New York state and Ontario, where it is highly prized as a pasture and hay grass. It will grow under more adverse conditions than Kentucky blue-grass, withstanding drought and summer heat, and doing well on poorer soils. It is primarily a pasture grass, and its main usefulness is where Kentucky blue-grass will not thrive. The methods of growing and handling are the same as for Kentucky blue-grass, from which it is distinguished by its flattened stems, and its bluish-green color.

TEXAS BLUE-GRASS. Texas blue-grass is a native of South Texas and Oklahoma. It is a perennial, very similar to Kentucky blue-grass, except that the plants are larger and coarser but not so aggressive. The high cost of the seed has prevented its use to any great extent, so that it is grown only where it spreads naturally, and there used mainly as a pasture grass.

FOWL MEADOW-GRASS. Fowl meadow-grass, or late meadow-grass or fertile meadow-grass, is a perennial grass native to both America and Europe, thriving wherever the summers are not too hot; it does not succeed in the Southern states. It is especially adapted to wet meadows or bottom land, and like Kentucky blue-grass, is slow in making a sod. As hay it yields from 1 to 3 tons per acre. When sown, it is usually included in mixtures with other grasses and clovers.

ROUGH-STALKED MEADOW-GRASS. This is a European perennial grass, very similar to Kentucky blue-grass, except that its stalks are rough near the head, and that it has no underground runners. It is adapted to moist soils and moist climates. In Europe, it is of more importance than Kentucky blue-grass, but it is unlikely that it will ever be found valuable in this country.

WOOD MEADOW-GRASS. Wood meadow-grass is a perennial grass native to both Europe and America, and in this country is found from Minnesota to Pennsylvania and in Colorado. It grows in shady places quite well, but does not withstand heat so well as Kentucky blue-grass.

TALL OAT-GRASS. Tall oat-grass, also known as tall meadow oat-grass, false oat-grass, French rye-grass, and, in the South, evergreen-grass, is a deep-rooted perennial grass growing 4 feet tall, having a wide distribution in Europe, but not grown extensively in this country, except in mixtures. It has about the same adaptation to climatic conditions as orchard-grass. It is quite drought resistant, second only to brome-grass in this respect. It prefers loose, deep loams and clay loams, and does not succeed on wet soils, though it does well even on poor land. It does not tolerate shade, and therefore, should not be sown with a nurse crop. Sow in the early spring on a well-prepared seed-bed, about 40 pounds per acre, covering the seed an inch deep.

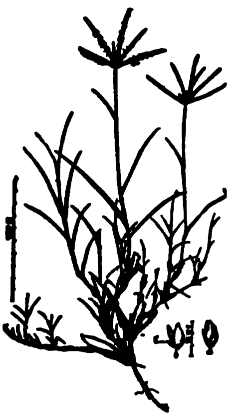


Fig. 277. Bermuda grass

Tall oat-grass is primarily a hay grass and usually makes 2 cuttings, but under favorable conditions 3 or even 4 can be secured. Cut when in bloom, and cure like timothy. The average yield when it is grown alone ranges from 1 ton to 3 tons per acre. Tall oat grass is more often sown in mixtures than alone because of its bunchy habit.

JOHNSON-GRASS is a perennial adapted to the cotton belt. It is difficult to eradicate, once started, so that it is seldom sown; but where established it is utilized both for hay and pasture. It will not withstand the winters of the north corn belt. On rich soils it yields as much as 6 tons; elsewhere about 3 cuttings of about 1½ tons per acre each.

Fig. 278. Tall oat-grass

BERMUDA-GRASS is a long-lived perennial, growing 6 to 18 inches tall, widely spread over all the southern states. It is to the cotton belt what Kentucky blue-grass is to the corn and grain belts—the most important perennial grass. It makes the best growth on rich bottom lands, well supplied with moisture, although the land must be drained. It makes excellent pasture, withstanding close grazing or cropping very well; it is also much used as a lawn grass. Bermuda-grass is usually established by planting pieces of roots in furrows 2 or 3 feet apart. The average yield is not more than 1 ton of hay per acre.

MEADOW FESCUE. Meadow fescue is a deep-rooted, long-lived perennial grass, growing from 18 to 24 inches tall. It makes a fairly good sod, withstands pasturing well, and if cut for hay, makes a good aftermath. It has practically the same adaptation as timothy, but is seldom grown alone except for seed. Fall seeding on a well-prepared seed-bed, at the rate of 15 pounds per acre, is preferred. Cut for hay just as it comes into bloom. It yields from 1 ton to 3 tons per acre. In Kansas, the crop is harvested for seed, handled like timothy, and yields an average of from 8 to 12 bushels per acre. Meadow fescue begins growth early in the spring, and continues late in the fall, and is probably a better pasture grass than hay grass.

OTHER FESCUES. *Tall fescue* is similar to meadow fescue, but grows 6 to 12 inches taller. It has not gained wide distribution, because of the high price of seed, but does as well as, or better than, meadow fescue, and is more rust resistant. *Reed fescue* is a larger and coarser grass than meadow fescue, although by some considered a variety of it. It yields more, but the hay is not palatable to all kinds of stock. *Sheep fescue*, under which name are included a large number of fescues, is sown for pasturage only, and is adapted to poor sandy soils or gravelly soils that will not grow better grasses. It is too small for hay, but is good as a pasture grass, withstanding grazing and tramping very well. It is a northern grass, not worth growing farther south than

FIG. 279. Fescue grass

northern Missouri, Illinois, and Kansas. *Red fescue* is a long-lived perennial, used in Europe as a pasture plant, but in this country mostly as a lawn grass on sandy soil near the seacoast of northern U. S. and Canada.

LESS IMPORTANT GRASSES AND HAY PLANTS. *Perennial rye-grass*, contrary to its name, does not resemble rye. It is a short-lived perennial, primarily adapted to moist regions with a mild winter climate. In America it is of little importance except as lawn-grass mixtures, although often it is included in meadow or pasture mixtures. It grows from 18 to 36 inches tall, and makes a good quality hay. *Italian rye-grass* is a biennial, similar in other respects to perennial rye-grass. It is of little importance in the United States excepting in the Pacific Coast States, where it is found in meadows. *Slender wheat-grass* also known as western rye-grass, is a native perennial grass, grown to a considerable extent in the Dakotas and Canada. It is usually seeded in the spring, 10 to 30 pounds per acre, broadcast, and harrowed in; or drilled, on a well-prepared seedbed. Yields vary from 1 to 4 tons per acre, averaging 2½ tons on a fertile soil. It gives good results in mixtures. *Western wheat-grass* also called blue-stem or blue joint grass, resembles slender wheat-grass somewhat, but has creeping rootstocks by means of which it spreads. It is native over practically all of western United States, and is somewhat resistant to both drought and alkali. *Meadow foxtail* is a long-lived perennial grass, producing loose tufts with many leaves, and growing 3 to 6 feet tall. It is an important grass in northern Europe, but is grown very little in this country. *Sweet vernal grass* is a long-lived perennial, 18 to 20 inches high, one of the very earliest to start in the spring. It is grown very little in this country, and is never sown alone. *Reed canary grass* grows in wet places, especially river bottoms and lake shores, where each plant may form a dense clump 1 to 2 feet in diameter. It is adapted to cool climates. *Velvet grass*, known on the North Pacific Coast as mesquite, is a perennial adapted to cool, moist climates, and is not intentionally sown, since it is eaten but little by animals. It is very aggressive, but the yields are small. *Erect brome grass* has not been grown in America to any extent. On good land, other grasses yield better; but on poor land it does better than most grasses. *Yellow oat-grass*, practically unknown in America, is a long-lived perennial, drought-resistant, and of only secondary importance even in Europe. *Crested dogstail* is a European grass adapted to cool, moist regions, but not thriving in America. *Japanese sugar cane* is a southern perennial, succeeding on almost any type of soil. Since it does not bloom in this country, it is planted by laying the old canes in furrows 6 to 8 inches deep. The crop is utilized as dry fodder, silage, or pasture. *Carpet-grass* is a perennial, widespread in the Southern states, requiring plenty of heat and moisture for its best growth and utilized as pasture. *Paspalum*, known also as large water-grass and golden crown grass, is a Southern perennial, growing in clumps 2 to 4 feet high. It is a desirable pasture grass. *Para-grass* is a tropical grass adapted to wet or moist land. It makes a very coarse and rapid growth, but is readily eaten. It is propagated by cuttings of the long, underground runners. *Guinea-grass* is a long-lived perennial with creeping underground runners grown along the Gulf Coast. It is not adapted for hay, but makes a fair soiling crop. *Rescue grass* is a short-lived perennial, behaving as an annual under cultivation, adapted to humid regions of mild winters. It is a desirable grass for mixed pastures. *Crab grass* is an annual grass, never intentionally sown. It makes an abundant growth, and is widely utilized as hay over the South. *Natal grass* is an annual, adapted only to the Gulf Coast region, and similar to crab grass, but larger. It is considered excellent for fall and winter grazing. *Alfilaria* is an annual forage plant, said to be of promising value, which is gradually spreading on the ranges of the Southwest. *Florida beggarweed*, an annual, is a tall meadow plant adapted to the rich moist lands of Florida and the Gulf States. *Salt bush* is either an annual or perennial plant adapted to the strongly alkaline lands in the arid regions of the United States.

FIG. 280. Perennial rye-grass

FIG. 281. Italian rye-grass

Spurry is an annual, used for pasture, hay, or seed. It is adapted to sandy lands in regions having a cool, moist growing season. In Europe it is employed as a catch crop or green manure crop. *Teosinte* is a coarse annual grass, resembling corn. It requires a long, moist, hot season to mature. It is used in the same way as sorghum (see below). *Jerusalem artichoke* (p. 378) as a forage is valuable chiefly for hogs. After the tops are killed by frost, the hogs are turned in to harvest the tubers.

RAPE. Rape is a native of temperate Europe, either annual or biennial, and best adapted to a cool growing season on rich moist soils. It is often seeded in a grain crop, being broadcasted at the rate of 3 to 4 pounds per acre either at the time of seeding the grain or after the latter is 2 or 3 inches high. With a favorable season, good rape pasture is obtained in 2 to 3 weeks after harvesting the grain. Rape is commonly utilized as a pasture for sheep or hogs. Yields range from 5 to 30 tons per acre of green fodder. Rape may also be drilled alone using not more than 5 pounds of seed per acre, in which case pasture can be had more quickly.

SORGHUM is an annual forage crop grown most extensively in the drier regions of Kansas, Nebraska, Oklahoma, and Texas. In the Old World, sorghum is cultivated for grain, sirup, or for brooms; but in this country it is grown mostly as a forage crop, although a part is grown for brooms (p. 225), and a smaller part for grain (p. 224). It is of immense value in America because of its drought-resistance, which suits it to regions where corn cannot be grown. In states as far north as Iowa, Illinois, Indiana, and Ohio, it is most satisfactory to grow as an emergency hay crop, and will produce larger yields of palatable and nutritious forage than most annual grasses. Sorghum is best adapted to regions having a warm summer climate, and in general, its soil adaptations are the same as those of corn. Some types of sorghum withstand hot, dry weather much better than corn.

Preparation of soil. Sorghum grows very slowly at first; therefore the seedbed should be prepared even more thoroughly than for corn. Seeding should not be made until the ground is warm, usually a few weeks after corn-planting time. A fair crop can be obtained even when seeded as late as the latter part of July.

Seeding. For forage, sow sorghum broadcast, or, better, with a grain drill, at the rate of 30 to 90 pounds per acre. The thicker the seeding, the finer and the more palatable will be the stalks. If broadcasted, cover with disc or harrow. Another method of seeding is to drill in rows with a corn planter, the rows being cultivated like corn. There is some advantage in growing sorghum in rows, since the crop is handled easier in the harvest.

Harvesting. In the North, only one cutting of sorghum is possible, but in the South, where moisture is ample, 2 or 3 cuttings are secured. When in rows, a good way is to cut with a corn binder, and place in shocks to cure. When drilled or broadcast, handle like hay, or better, cut with a grain binder, taking about 2 or 3 feet in a swath. Then the bundles may be shocked in the field to stand until the succulent stalks are thoroughly cured. It is not safe to store sorghum in a barn or to stack it;

FIG. 282. Teosinte, a grass that resembles corn

it is therefore fed directly from the field. Sorghum ordinarily yields from 2½ to 4 tons of cured hay per acre, or even more on very fertile soils with abundant rainfall. The seed costs from 5 to 10 cents per pound.

Care must be exercised not to pasture sorghum which has been stunted by drought or frost, since prussic acid sometimes develops in the leaves under these conditions. The poisonous property disappears when the sorghum is mown and allowed to lie until cured.

SUDAN GRASS. Sudan grass is an annual grass, belonging to the sorghum family. It was first introduced in 1909, being grown that year on a government experiment station in Texas, where it proved well adapted to hot, dry-weather conditions. Its spread throughout the semi-arid Southwest has been rapid. In states as far north as Iowa and Illinois, it

FIG. 283. Florida beggarweed

seems to be a promising forage crop, of considerable value as an emergency hay crop, making hay quite comparable in quality with timothy. Compared with millet, the growth is taller, leafier, and more luxuriant, and the yield is greater. The stalks are much finer than those of sorghum, and for this reason equally heavy yields of hay can be cured easier than with sorghum. It stools abundantly, growing from 4½ to 8 feet tall, and, under very favorable conditions, even higher. Sudan grass is adapted to the same general conditions as sorghum, but as a forage crop it can be grown farther north than sorghum, since it matures earlier by 2 weeks. It deserves a place on the farm as a "catch crop" for hay, because it can be substituted for other hay crops which have failed to make a good stand.

Like sorghum, it has a comparatively shallow root system, and makes a slow growth at first; therefore a well-prepared seedbed is necessary. Fall plow if possible, and work the ground every week or 10 days until time of seeding. If spring plowing is necessary, delay it until the weeds have started, then plow them under; this is important, for it is quite easy for weeds to get a start on Sudan grass. Once started, however, no weed can compete with it. The largest yields in the northern sections are obtained by drilling in rows, 36 inches apart, and using not more than 10 pounds per acre. A quarter as much has given satisfactory results under favorable conditions. Sow Sudan grass about corn-planting time, or a week later. The soil requirements are quite similar to those of corn; like corn, it will make the best growth on fertile ground. Two cultivations will probably be necessary; after that, the growth shades the rows so that further cultivation is unnecessary. Good results may also be secured by seeding like small grain, either drilled or broadcast at from 10 to 25 pounds per acre. If broadcast, cover the seed with a harrow. When broadcasted, the hay is much finer in quality, and the yields are almost as great as when drilled in rows.

Sudan grass is ready to harvest for hay when in full bloom, but where one expects a second cutting, it is best to cut as soon as the heads appear. Early cutting of the first crop provides more favorable growing conditions for the second growth, and also gives a more palatable feed. When seeded in May, one can expect to harvest 2 cuttings of hay, making a total yield of from 2 to 4 tons per acre. Ordinary haying machinery is used. Under favorable conditions, a fine quality hay can be made by cutting with a binder, and shocking to stand and cure. It is not a successful practice, however, with the first cutting. In harvesting the seed crop, the largest amount of good-quality seed can be obtained by cutting soon after the earlier heads are fully mature. Use the binder and leave the bundles shocked in the field until ready for threshing. The ordinary threshing machine can be adjusted for Sudan grass by regulating the wind so that it will not blow over the seed with the chaff. The yield of Sudan grass seed will vary from 200 to 600 pounds per acre, while it sells at from 10 to 40 cents per pound.

When the forage is harvested as hay or cut and fed green, it has a feeding value similar to that of sorghum, and higher than that of timothy hay. It is especially well adapted for feeding cattle and horses.

MILLET. Millet is a general term covering 3 groups of annual grasses closely related to the wild foxtails and barnyard grass. In this country it is grown mainly as a forage or hay crop, though the larger-seeded varieties are fed to stock to some extent. As a "catch crop" it is especially useful because it can be substituted for other crops which have failed to make a good stand, and thus bring a return from land which might otherwise lie idle. It is also useful for getting new land under control, freeing it from weeds, and improving its tilth. In Asiatic countries, especially Japan, China, and India, the various millets are important as cereal grains, the use of millet seed as a human food going back into the earliest history.

Types and varieties. The millets are divided into 3 groups mainly according to the general appearance and habit of growth of the heads. (1) *Foxtail* millets, including Common, German, Siberian, Aino, Kursk, Golden Wonder, and Hungarian, have relatively compact and cylindrical heads. They require a rich, warm, loam soil and a moderate moisture supply for best results; they stand heat and sunlight well, but cold weather injures young

FIG. 284. A field of Sudan grass

plants. In height they range from 2 to 3½ feet and under favorable conditions they may be cut for forage in 4 to 6 weeks. (2) *Barnyard* millets contain all varieties having large, irregular, more or less "open" or branching heads such as the Japanese, Ankee, Shama or Jungle Rice and Sanwa. The first two withstand considerable alkali in the soil but do not endure drought. The softness and juiciness of these millets makes them hard to cure as hay; wherefore they are grown mainly as a soiling crop to be fed green. They range in height from 2 to 4 feet. (3) The *Broom-corn* or *Proso* millets are the "common millets" of the Old World. They have loose or open heads; the seeds are borne at the ends of comparatively long slender branches, are larger than those of the other millets, and show a wide range of color from white through the various shades of yellow, red, brown, and gray to black. The best known varieties are Black and Red Voronnzeh, Red Russian, Tambav, Manitoba, White French, and Early Fortune, which range in height from 1½ to 3½ feet and vary widely in length of growing season. In general they are very drought-resistant and well suited to high altitudes; when grown for seed they yield as high as 50 to 60 bushels per acre.

In addition to these three groups another grass known as Pearl millet, Egyptian millet, cat-tail millet and Mand's Wonder Forage Plant—but which is not a true millet—has recently become important because of its enormous yields and because it may be cut 2 or 3 times in a season. This millet (so-called) ranges in height from 6 to 15 feet, with an erect, cylindrical, compact head that may reach a length of 12 inches. It becomes woody and coarse after heading out so must be cut early for hay, but when so handled it is hard to cure because of its succulence.

How to grow it. Millet is a shallow-rooting crop, therefore give it a well-prepared soil—preferably loam—in which the plant food is near the surface. Delay spring plowing until weeds are well started, then prepare the land about as for corn. Millet is usually seeded in northern United States soon after corn, for the young plants are very sensitive to cold. It is customary to drill it at the rate of 2 pecks per acre of foxtail or proso, and 3 pecks of barnyard millet. When grown as a catch crop, rather more seed is usually broadcasted on newly-disked stubble, then harrowed in. Cut millet for hay when well headed out, but before the seeds begin to ripen. Over-ripe millet, especially of the foxtail group, injures horses' kidneys if fed for considerable periods. Also the beards of this type are indigestible and liable to form balls in the stomach. For a seed crop, harvest when in the "stiff dough" stage using a self-binder.

As a hay crop, millet compares favorably with any of the other coarse grasses in palatability and feeding value and outyields most of them; barnyard millet may make 4 to 6 tons of cured hay per acre, the others slightly less. When seeded with a legume such as soy beans, field peas, or clover, it makes good pasture for hogs, calves, or sheep; the same mixture has given good results in the silo, and is useful in regions not suited to corn.

The ground seed of the various millets, especially the broom-corns and prosos, is popular as feed for young cattle and hogs in sections where good corn cannot be matured. This use has given rise to the name "Hog Millet" in the Northwest. The smaller seeds of the foxtail millets are seldom fed to stock but are generally used for poultry feed. It is claimed that they are effective in stimulating egg production. (By J. H. H. Alexander.)

FIG. 285. Millet heads of two types: *a Hungarian; b Barnyard*

D. FORAGE CROPS: THE LEGUMES

By **Samuel Fraser** *(see Chapter 25) whose articles are followed by the letters* S. F.; *and* W. L. **Nelson** *(see Chapter 11), indicated by* W. L. N. *After working as a farm hand on general and truck farms near Manchester, England, Mr. Fraser studied at the Cheshire Dairy Institute and later at the Cheshire Agricultural College working his way as assistant to the Principal and later as instructor. Taking part in the annual examinations held by the Royal Agricultural Society of England and the Highland and Agricultural Society of Scotland, he won the Silver Medal of the former society, and the Diplomas and Life Memberships of both, being the leading agricultural student of his year in Great Britain. He also secured the National Diploma in Dairying and the Bronze Medal in Agriculture from the Science and Art Department, South Kensington, London.*

After a year in Ireland in the butter business he came to America where for about 3 years he was Agriculturist of the Briarcliff Manor School of Agriculture and Horticulture in New York. Later he was for 3 years Assistant Agronomist and Instructor in Agronomy at Cornell University devoting special attention to root crops and grasses, especially tim othy breeding. Later for 8 years he was on the Estate of Major W. A Wadsworth, Geneseo, New York. At present he is operating his own farms and extensive orchards in western New York, having for the past 10 years been interested in the production of nursery stock.—Editor.

THE legumes come of a family of plants (*Leguminosa*) containing several thousand species, all having the same distinguishing characteristic in the structure of the fruit or pod, which is bean-shaped and bears a row of seeds on the inner front surface. Generally the flowers are butterfly-like; common peas and beans are typical. Plants of this family differ greatly, as witness the beautifully colored sweet pea and the locust tree. The legumes in which we are interested because of their agricultural importance, and which are discussed in this chapter, are alfalfa, berseem, the clovers, cowpeas, Kudzu, lespedeza, lupine, the medics; peas, peanuts, sainfoin, serredella, soy beans, velvet beans, and vetch. All these have a peculiar value because of one property which they possess: all are nitrogen gatherers, that is, they have the power of "fixing" the free atmospheric nitrogen contained in the soil, thereby enriching the land. When we consider how necessary nitrogen is in plant growth and how costly when bought in the form of commercial fertilizers, we can better appreciate the importance of the leguminous crops.

Fig. 286. Roots of a leguminous plant showing the bacterial nodules.

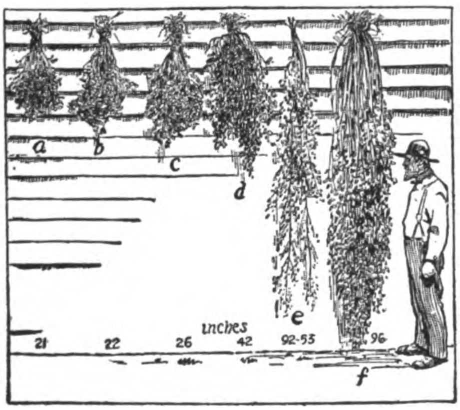


Fig. 287. Showing the comparative top growths of various legumes: *a* alsike clover; *b* red clover; *c* mammoth (scarlet) clover; *d* alfalfa; *e* yellow sweet clover; *f* white sweet clover. (International Harvester Co.)

Bacteria. Bacteria which have their homes in the root tubercles or nodules, are the active agencies by means of which the work of nitrification is carried on. On carefully examining the roots of vigorous, well-established legumes, we may notice on them galls, knots, or nodules varying in form and numbers. Formerly these nodules or tubercles were thought to be the result of disease or the work of insects. Now, we see in these nodules, not disease, but active soil-building and crop-increasing agencies.

In growing legumes it is important that conditions be made such as to encourage bacterial growth, without which legumes may, like many other crops, become soil robbers instead of soil builders. Inoculation, then, may be necessary. By inoculation is meant the introduction into the soil of

living bacteria of the proper kind. In other words, we provide a "starter"—live bacteria—just as we do by means of yeast in making bread. Carrying the comparison farther, we may use a homemade yeast or buy the manufactured yeast cake—take soil from an old field or purchase pure cultures. In either case, since there are many races of nodule bacteria, we must be certain that we have the proper one for our purpose. As each legume, with probably a few exceptions, has its own specific organism, failure to provide such may result in disappointment. Bacteria that are effective on cowpeas would be valueless on alfalfa, and so on throughout the long list. There are, however, one or more exceptions; the bacteria of sweet clover, for instance, will work on alfalfa.

Methods of inoculating. One method of inoculating is to secure soil from the top 3 or 4 inches of a clean, vigorous field, where the crop which we wish to grow has become well established. This soil is then broadcasted over the surface of the new field at the rate of 150 to 500 pounds per acre. The work should be done on a cloudy day or late in the afternoon, and the field should immediately be harrowed, as the direct rays of the sun will kill exposed bacteria. About the only objection to this method is the danger of introducing fungous diseases or weed seeds.

A modified form of this method, one which necessitates less hauling, but which is somewhat troublesome, consists in inoculating the seed by using a small quantity of soil, as follows: For a bushel of seed dissolve a dime's worth of furniture glue in a gallon of hot water. Sprinkle this glue over the alfalfa seed, and stir and work it until all of it has been thoroughly moistened. Next sprinkle the soil over the seed and stir it until it is covered with dust. Continue to stir until the individual seeds are so dry that they will not stick together.

The use of pure cultures constitutes a third method of inoculation. Directions for the use of these cultures accompany each package, tube, or bottle purchased, and, when carefully followed and used within the time specified, should give good results.

Importance of the legumes. As the leguminous crops come to be better understood, and as long-continued cropping robs the soil of much of its fertility, they are sure to be more generally grown. The legumes are nature's great soil restorers, improving the tilth of the soil, adding valuable plant food, and making more available useful elements already in the soil.

Not only are they important as nitrogen gatherers, but they are highly important for green manuring. No crop rotation should be considered complete without a legume. Fortunately, too, there is some legume that is suited to practically every climatic condition in the United States, and in most sections the farmer may choose from several. Gradually, through a better understanding of the crop requirements and by developing hardier varieties, we have been enabled to grow alfalfa, soy beans, cowpeas, and other legumes where it was once thought to be impossible to do so.

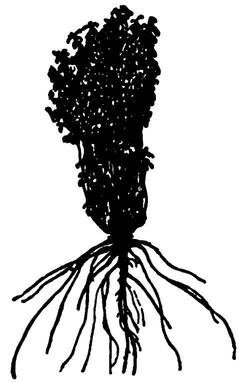


FIG. 288. A single alfalfa plant 4 years old

Wherever grown, the leguminous crops gain in popularity, so that everywhere the acreage in them is increasing. In any plan of permanent and profitable agriculture they must of necessity have a large part. (S. F.)

ALFALFA. Alfalfa is a long-lived, deep-rooted leguminous perennial plant, growing from 1 to 4 feet high. The long taproot, which makes alfalfa an excellent drought-resister, is characteristic of practically all varieties. Leaves are pinnate or feather-shaped and in groups of threes. Blossoms, except of a few varieties, are violet and are borne in compact, oblong clusters. Seed pods are quite small, slightly hairy, and spirally coiled in 2 or 3 turns. Seeds are kidney-shaped and about one twelfth inch long. In appearance (except of blossom) alfalfa resembles sweet clover, but lacks its pungent odor.

The history of alfalfa goes back to 500 B. C., at which time it was grown in Media, now northern Persia. During more than 2,000 years alfalfa was making its way in a zigzag course across or into Asia, Europe, and Africa. It was introduced into England about 1650, and, from Spain, soon reached Mexico and Central America. Next it spread to Chile, from which country gold-seekers, rounding Cape Horn, probably introduced it into California about 1850. Previous to this, though, it is said to have been tried out in the eastern portion of the United States with varying degrees of success.

Alfalfa, the most valuable of the medics, is known in England as "purple medic," and lucerne under which name it may have reached southern Europe. The word "alfalfa," by which the plant is known in America, is of Arabic origin and means "best of fodder." The distribution of alfalfa throughout the United States is widespread, including more than three fourths of the states. It is extensively grown in Kansas and Nebraska and in the states to the west, Kansas leading with 1,359,498 acres in 1915.

Soil requirements. Alfalfa, though not hard to grow, is rather exacting in its soil requirements. It does not do well on soil that is wet, sour, poor, or weed-infested. It gives best

FIG. 289. Inoculating a field for alfalfa by sprinkling soil from a field in which it grows, and immediately harrowing it in.

results on a deep, fertile, well-drained soil rich in lime and free from any impervious hardpan layer. While not exacting as to soil texture, it prefers loam, silt loam, or sandy loam. The water level should be comparatively stationary—not too near the surface, nor yet too low—for, while moisture is essential, alfalfa will not stand "wet feet." If free water is too near the surface, or if it occasionally rises to a point nearer than 3 or 4 feet of the surface, it may cause the taproot to decay. Alfalfa is killed by water standing on it even for a brief period, especially during warm weather. Lime is essential. If soil is sour, lime must be supplied, since the bacteria which cause nitrification cannot thrive in acid soils. Plants such as sheep sorrel and sour dock indicate soil acidity. There are also methods for soil testing. Of these, the use of litmus paper is one of the simplest (p. 91). Ground limestone applied at the rate of 1 to 3 tons per acre or, in fact, in almost any reasonable quantity, may be used in correcting soil acidity. Thoroughly disc in lime several weeks in advance of sowing alfalfa.

In building up a poor soil preparatory to growing alfalfa there is nothing better than well-rotted stable manure. Owing to danger from weed seeds in manure a good plan is to apply it to some preceding crop, such as corn. In the heavy alfalfa-growing states commercial fertilizers are but little used. However, some commercial fertilizer rich in phosphorus, such as bone meal or acid phosphate, might be used with profit. The late Joseph E. Wing said: "We have found that it pays very well, indeed, to apply phosphate at the time of seeding. Either the acid rock or bone meal may be used with excellent results."

Getting a start. The importance of a well-prepared seedbed for alfalfa cannot be over emphasized. The surface of the ideal seedbed is loose, mellow, and finely pulverized, but below this it is thoroughly firmed. When plowed deep, the plowing should be done well in advance of seeding. The alfalfa seed is very small, and the young plant is unable to fight weeds and grass, enemies more easily prevented than driven out. Frequent stirrings of the ground, especially after each shower, for several weeks in advance of seeding will cause most weed and grass seeds to sprout. Moisture will also be conserved and the seedbed firmed. Only good seed should go into a good seedbed. The variety of the seed, except where some one quality such as hardiness is sought, is less important than the quality. The names of most so-called varieties refer to regions where the seed originated, as Arabian, Peruvian, Chilean, and Turkestan. To this rule Grimm is an exception, alfalfa now known by this name having been introduced into Minnesota in 1857, by Wendelin Grimm, an immigrant from Baden, Germany. It is very hardy and well adapted to northern conditions. The state in which commercial alfalfa seed is grown may also lead to a domestic strain name, as Utah-grown or Nebraska-grown. Seed grown under irrigation is generally regarded as inferior to that produced under ordinary methods of culture.

Adulterants in seed. These should be guarded against. Common adulterants are foxtail crab grass, pigweed, Russian thistle, dodder, and buckhorn. A good plan to ascertain quality is to send samples of alfalfa seed to a government seed-testing laboratory for official test.

Inoculation. Inoculation, while not practised by all growers, will pay, especially in districts where alfalfa is being grown for the first time, where it is not generally grown, or where there is no natural inoculation. Methods of inoculation have been described at the beginning of this chapter.

Methods of sowing. The amount of alfalfa seed sown per acre varies from 6 to 30 pounds, 15 pounds being a fair figure for seed of good quality. In Kansas, the average amount of seed sown per acre is about 15½ pounds. Seed is either drilled or broadcasted. Where drilled, an ordinary grain drill with grass-seed attachment is preferred. In broadcasting, various types of seeders, such as hand seeders, wheelbarrow seeders and end-gate seeders are used. A good plan is to sow half the seed each way—half north and south, and half east and west. This

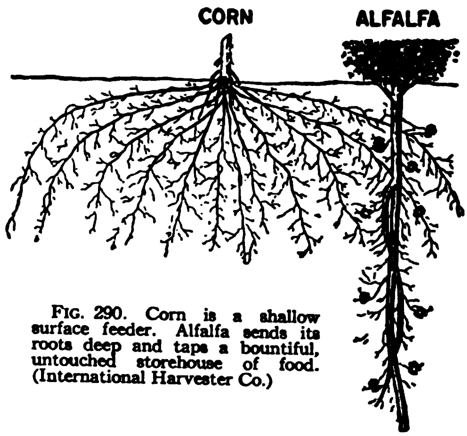


FIG. 290. Corn is a shallow surface feeder. Alfalfa sends its roots deep and taps a bountiful, untouched storehouse of food. (International Harvester Co.)

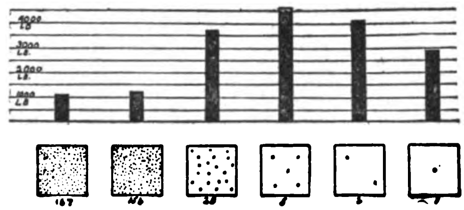


FIG. 291. The effect of thickness of seeding on the yield of alfalfa. The black columns show the yields when there were planted, per square foot, 167, 156, 20, 5, 2, and 1 seed respectively. (Kansas Report.)

insures a more even distribution. Care must be taken not to cover the seed too deep.

When to sow. Alfalfa is sown in spring or fall. Spring sowing is frequently with a nurse crop of oats or barley used in half the ordinary amount. In spring sowing there is less danger of winterkilling, but grass and weeds are more troublesome. Less labor is required, but the work comes at a very busy time. Spring seeding varies from March 15 to June 1; fall seeding, from about August 15 to September 15. Cultivation may be advisable, but harvesting at the proper time constitutes the principal care of the alfalfa crop. Where grass is troublesome some cultivation may be required, but as to methods and amount of cultivation growers are not agreed. Climate and soil conditions must determine. In a humid territory severe treatment, such as splitting the crowns, results in decay. The spring-tooth harrow is very efficient in removing weeds and grass without undue injury to the plants. Special alfalfa renovators and spiked discs are also on the market.

Harvesting. There are three guides as to the proper time for cutting alfalfa. Experienced growers regard the new shoots as the best test, the rule being to cut when these appear. Using the blossoms as a guide, the custom is to cut when a tenth to a half of the plants are in bloom, the latter where alfalfa is to be used principally for horse feed. Yellow lower leaves on standing growth indicate need of cutting. Where seed is the object, the crop is left until two thirds to three quarters of the pods have turned brown. In seed-producing districts the average yield of seed is about 4 bushels per acre. In harvesting alfalfa, care should be taken to avoid all unnecessary handling of the leaves; for while only two fifths of the total weight of the plant is in the leaves, three fifths of all its protein is contained in them. In curing, the best hay is made when the leaves wilt, rather than bake, under a very hot sun. After alfalfa has been let lay for several hours, it should be raked into windrows, and, when sufficiently cured, placed in stacks, sheds, or mows. Where acreage is small, alfalfa is sometimes placed in cocks. Hay caps, or cock covers may be made of yard-square muslin and held in place by a

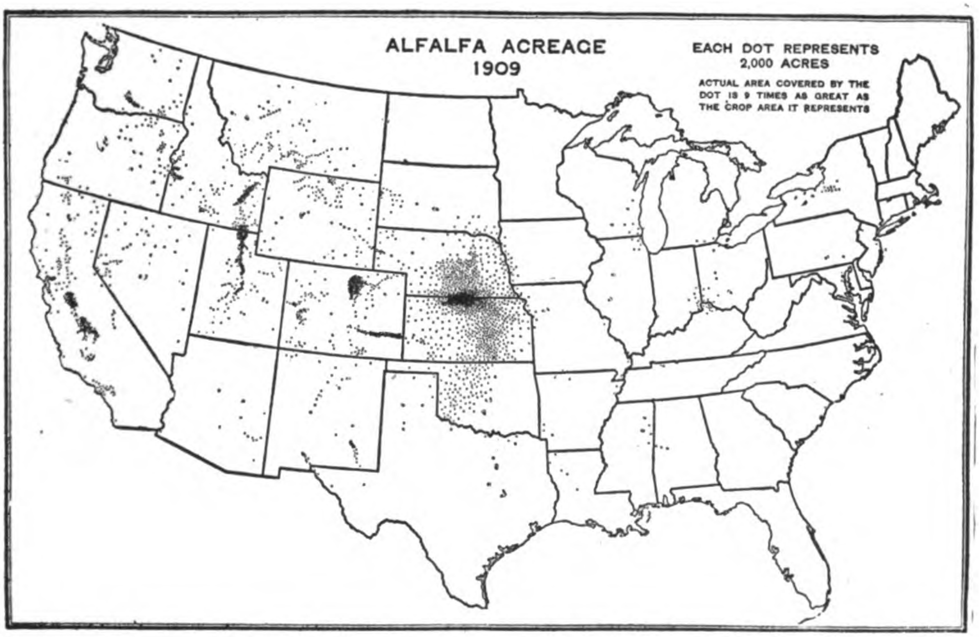


FIG. 292. The importance of alfalfa is still greatest in the West, especially the irrigated sections, but its popularity and success are gradually spreading over all parts of the country where forage crops are grown either for sale or for feeding on the farm. (1915 Yearbook, U. S. Dept. of Agr.)

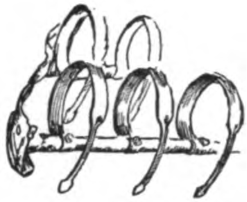


FIG. 293. Part of an alfalfa harrow showing modified spring teeth.

wooden pin tied to each corner and driven into the ground. Alfalfa is sometimes baled direct from the field; but except under unusual conditions this is not to be recommended. Hay dry enough to cure in the field will lose a great many leaves in handling, while hay baled when it contains sufficient moisture to prevent loss of leaves may mold in the bale. A common type of bale is oblong, measuring 16 by 18 by 36 inches and varying in weight from 65 to 85 pounds. From 3 to 5 cuttings of alfalfa are made in one season. In Kansas, the average reported yields for 5 cuttings were 1.25, 0.98, 0.82, 0.63, and 0.53 tons respectively. The average number of cuttings for the state is 3.72. The last cutting should not be made too late in the season. It pays to leave some growth for winter protection. Seed is generally saved from the second cutting. In threshing, an alfalfa or clover huller is used. Many late model grain-threshing machines are equipped with special alfalfa attachments. Where cuttings are made at the proper time and where conditions are favorable, alfalfa will continue for years. The ordinary life of a field is from 5 to 15 years, but Kansas has one field whose age is known to be 43 years.

Feed value. According to Prof. W. A. Cochel, of the Kansas State Agricultural College, "on soils where it can be successfully grown, alfalfa produces the greatest yield of protein per acre of any crop which the farmer or the scientist has yet discovered." It is valuable as feed for practically all kinds of live stock. Rich in protein, bone- and muscle-building material, cured

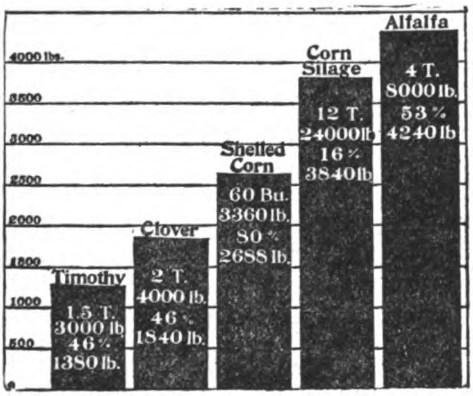


FIG. 294. Pounds of digestible nutrients produced in different crops on one acre. The white figures show yield in tons and pounds, the percentages of nutrients, and their actual amounts (Mo. Bulletin).

FIG. 295. Except in arid sections it is best to cure alfalfa hay cocks under caps. Tie a stone or chunk of concrete to each corner.

alfalfa enters into the making of many desirable balanced rations. It is also one of the best of late summer hog pastures. (W. L. N.)

BERSEEM. Berseem is a clover-like forage plant ranking well as a nitrogen gatherer and possessing unusual adaptability to alkali lands. It was introduced into the United States from Egypt, where it is extensively grown and from which country it takes the name of "Egyptian clover." It is now being grown in an experimental way in the Southwest. Growth, from 2 to 5 feet, is rapid until stopped by the heat of midsummer. In size and shape, heads resemble both common red and white clovers. Drilled or broadcasted at the rate of 15 to 20 pounds of seed per acre in late autumn, two cuttings are possible the next spring. Wet land is desirable; elsewhere irrigation is requisite. (W. L. N.)

CLOVERS. The plants treated under this head are the 4 more common members of the botanical genus Trifolium, namely red clover, alsike clover, crimson clover and white clover. There are less important forms

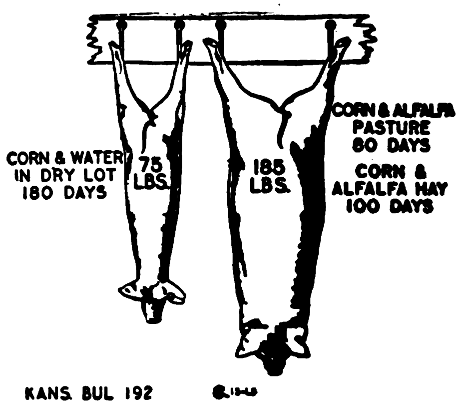


FIG. 296. Alfalfa balances the corn ration. These carcases show the results of two feeding systems on hogs that started even (International Harvester Co.).

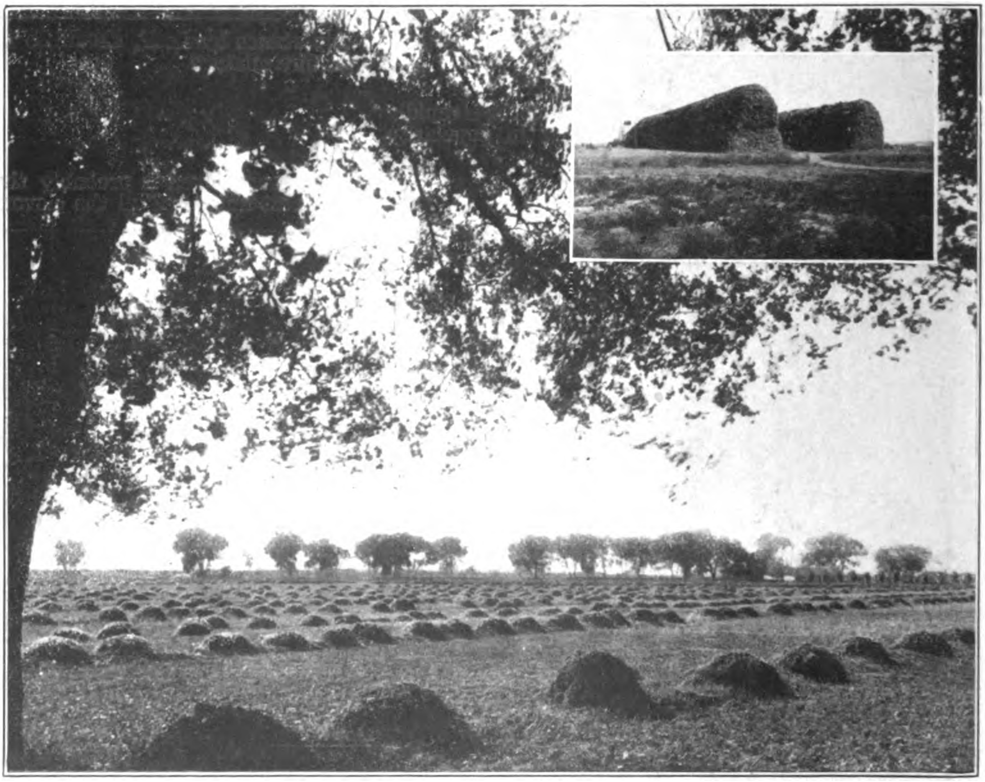
White clover, of limited importance by itself, should be in every pasture mixture

Sweet clover is rapidly gaining in popularity

Common red is probably the best known of all the clovers

The Clovers, Supplying Food for Livestock, for Bees, for the Soil, and Ultimately for Man, are Valuable Indeed

The godfathers of alfalfa in America: at the left, Hon. F. D. Coburn, of Kansas; and at the right the late "Jo" Wing, of Ohio



Wherever alfalfa has been fairly and squarely tried, it has come to stay

ONE FARMER (?) GAVE UP ALFALFA BECAUSE "WHENEVER HE WANTED TO GO SOMEWHERE, IT WAS TIME TO CUT IT!" WHAT DOES THAT TELL YOU ABOUT IT—AND HIM?

closely related to one or another of these. The name clover is also applied popularly to leguminous plants of other genera such as burclover which is really a medic (p. 264), and sweet clover (p. 267) which belongs to the genus Melilotus.

Red Clover. For three centuries red clover has been the renovating crop for the northeastern United States. It does not grow so well in the extreme Southern states, nor is it thoroughly established in all the central states, although very extensively grown there. The crop produces seed readily. According to the Thirteenth Census 1,025,816 bushels of seed were harvested in 1909, three fourths of this being produced in the east north-central states. The so-called red clover of commerce embraces plants which differ considerably in character; some are hairy, others almost destitute of hairs; some biennial and others perennial in duration; some tall-growing and some short; and in any sample of seed there are decided variations.

The crop is generally sown with a grain crop early in the spring, frequently on the snow, or about the time the land shows the honeycomb conditions so well recognized by farmers; in other words, at the time when there are frosts in the morning and the land is fit to walk on until perhaps 9 or 10 o'clock. Where the acreage is considerable an endgate seeder is used. Others use wheelbarrow or hand seeders. Seed sown in the late winter or early spring falls into cracks and crannies in the soil, and the freezing and thawing furnishes it with adequate cover. If sown alone, 8 to 12 pounds of seed per acre are used, but with timothy 6 to 8 pounds are usually considered ample. Seed should be free from buckhorn and other impurities. The clovers germinate best at a constant low temperature, and these conditions are best secured early in the spring when there is still apt to be some snowfall and a little rainfall to keep it sufficiently moist until it has established itself. Some, however, prefer to wait until later in the spring, then broadcast the seed and follow with a light harrow.

The plant is better adapted to loam soils than to heavy clay. It prefers a moderate climate and will not thrive as far north as alsike clover, nor endure as much moisture. On the other hand, it is less able to withstand heat and drought than is alfalfa. It is better adapted to a rich than a poor soil, and where land is too low in organic matter it soon dries out. On heavy, wet land, or where there is alternate freezing and thawing, it often heaves out in winter. A top-dressing of straw or well-rotted stable manure will aid in preventing this trouble. Liming of land will pay.

The crop is mown once or twice in a season. Frequently it is sown with timothy, so that the hay cut the first year is mixed clover and timothy. The second crop of clover which may come on is cut for seed, if it contains sufficient seed, and in the subsequent year the land is a timothy meadow. Clover hay is very easily discolored by rain, hence there is a tendency to rush the curing and to get it in as quickly as possible. If brought in too soon, it molds and becomes dusty, which renders it very poor feed for horses. It is usually mown as soon as the plants are well in bloom and before they have formed seed. If the crop is heavy, it is tedded immediately after cutting; and, if very heavy, it may be tedded twice. It is then raked into windrows and either loaded with the hay loader or bunched and allowed to stand in cocks for 2 or 3 days. Where acreage is

Fig. 297. An entire crimson clover plant (*a*), and a shoot of common red clover (*b*) showing the difference in flower heads.

large, 2-horse sweep rakes are frequently used. Hay should be placed in sheds or barns. The second crop may be cut for seed, and, in this case it is raked into windrows which are turned and then bunched. The straw is allowed to become thoroughly cured before being stacked or threshed. Where stacked in fields, covers for stacks must be provided, or timothy, prairie hay, or straw may be used in topping out.

A convenient way of mowing the seed crop, especially if a first crop is left for seed, is to cut it with a pea swather or windrowing attachment on the mower, which leaves it in windrows. These are then turned with a side-delivery rake or 3 of them are put together, or the crop may be bunched direct from them. Two to 5 bushels of seed is a fair crop, but 8 to 10 bushels may be secured.

Alsike Clover. On clay or other lands inclined to be wet, alsike clover is frequently

FIG. 298. Cowpeas sown between corn rows when the crop is laid by supply excellent forage and benefit the soil at the same time.

sown instead of red clover. It is distinguished by its forked stalks and pinkish blossoms. The hay is excellent, especially for horses. Only one cutting can be made in a season. The amount of seed sown per acre varies from 2 to 6 pounds in a mixture with timothy, redtop, or a mixture of these with red clover. Seeded alone, twice as much seed is used.

Crimson Clover. The crimson clover usually sown is an annual, although there are biennial and even long-lived strains. It is especially adapted to the sandy soils of the south Atlantic seaboard and central Atlantic and the middle-western states, where it is usually sown after an early crop, potatoes for instance, has been removed. It occupies the ground the succeeding fall and matures a crop of hay early the following spring. Twelve to 15 pounds of seed are sown per acre, the seed being the largest of all clovers. For hay, the crop is cut fairly early; if allowed to become too ripe, the blossoms may cause trouble in the digestive system of animals to which hay is fed.

The crop is profitable to cut for seed. It is used also as a soiling crop and for silage. It is a favorite in short rotations, especially on sandy loams and sandy soils along the Atlantic Coast.

White Clover. White clover, the smallest of its class, is a low-growing plant, usually annual, but perennial by means of its prostrate stems which root at intervals. It spreads both in this way and from seed. Its main value is as a pasture plant, especially in conjunction with Kentucky blue-grass. It is usually incorporated in most pasture mixtures at the rate of a pound or so per acre, and is of great value for bringing up the fertility of the pasture, as well as being relished by stock. (S. F.)

COWPEAS. Cowpeas are to the southern states what clover is to the states farther north. These annual leguminous plants, which are natives of Asia, where they have been cultivated for 2,000 years, are of great value in restoring the poorer soils of the southern agricultural regions. They are grown also as far north as Massachusetts and New York.

Planting. There are probably 100 varieties of cowpeas in cultivation. Some are erect in growth, some semi-erect, others trailing. The plant is quite susceptible to frost, and planting should be delayed until the ground is thoroughly warm. In the latitude of the central United States, planting may be made as late as July 1, but the general rule is to plant just a little later than for corn. The land is generally plowed in the spring, or it may be used for some early harvested crop and then fitted for cowpeas. In the more southern wheat states the planting of cowpeas immediately after the wheat is cut is a rather common practice. The amount of seed required depends upon the variety, whether the seed be large or small, and the method of sowing. When broadcasted or closely drilled, from 3 to 6 pecks per acre are needed. Sown in drills so as to allow for cultivation, 20 to 30 pounds will be sufficient. For hay or to turn under as a green manure, cowpeas are sometimes sown broadcast; but this is a wasteful practice, especially when seed is high in price. Drilling with an ordinary grain drill is much to be preferred. In some cases cowpeas are planted in corn for silage, usually about the time the last cultivation is given. In the corn belt, cowpeas planted with corn are largely used for fattening western lambs. Grown for hay, cowpeas are planted alone or with some other crop. In combination with German millet, seeded at the rate of 1½ pecks per acre, use 1 bushel of cowpeas. Another mixture is 1 bushel each of cowpeas and amber sorghum per acre. As a catch crop, where some other crop has failed or where a feed shortage is to be met, the cowpea is one of the best.

FIG. 299. White clover showing roots starting from two joints on the creeping stem.

Harvesting. For hay, cowpeas should be harvested when the first pods show signs of ripening. In harvesting, the aim is to expose the forage to the sun for as short a time as possible after mowing; thus the next day after mowing it is raked and put into cocks, where it will remain for 2 or 3 days, after which time the cocks may be turned over and then put into the barn if the weather

is favorable. In some cases, 3 poles are set like the supports of a wigwam, and the cowpea hay is piled round them. These large cocks, covered with hay caps, may be allowed to stand 2 or 3 weeks. In this way curing, which is often difficult, is simplified.

Harvesting for seed is delayed until many of the pods are almost ripe. The peas are raked and cured in cocks. They are then threshed with a special pea-huller, a flail, or a grain thresher with the concaves removed.

The cowpea is used for pasture, hay, and seed, also as a green-manure and cover crop. Some of the best seed-producing varieties are New Era, Black, and Whippoorwill. The Black, which is a very good producer of forage, is late; where very early varieties are required, New Era is one of the desirables. The pods and seed vary markedly in size, and the cowpeas may be white, yellow, red, brown, black, or shades between.

Cowpeas, like soy beans, constitute one of the most desirable crops that can be grown on the average farm. They are not soil robbers, but are exceedingly valuable as soil builders. This is especially true when they are grown on worn soils and turned under as green manure. Furthermore, the cowpea has come to be recognized as a real ready-money crop, owing to the high price commanded by seed and hay. Well-cured cowpea hay is relished by stock and is rich in food value. (W. L. N.)

KUDZU. Kudzu is a leguminous vine, perennial in nature and native to Japan, where, on rocky or other untillable land, it is grown for pasturage. Introduced into the United States 40 or 50 years ago, it has only recently come to be valued as a forage crop in the South. Farther north it is little grown, except in an ornamental way. As a field crop, kudzu puts out long branches which root at many of the joints and soon form separate plants. The result under favorable conditions is a dense growth, even when the original plants have been set 10 feet apart, as is recommended. In planting, well-rooted plants are best, as seed does not always germinate well. The leaves of the kudzu resemble those of the common bean, but are larger and tougher. Stems and leafstalk are hairy, as are the thin pods. Heavy

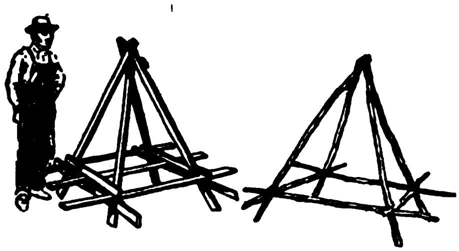


FIG. 300. Racks for curing cowpea and other leguminous hays. Knock-down, plank type (*left*); temporary type of poles tied together (*right*). (Tenn. Bulletin 82.)

FIG. 301. Cowpea plant showing ripe pods. (Farmers' Bulletin 318.)

yields of hay, with 2 or 3 cuttings a season, are reported from well-established fields in Florida. (W. L. N.)

LESPEDEZA. Lespedeza, an annual commonly known as Japan clover, is a native of eastern Asia. The date of its introduction into the United States is not established, but the plant is known to have been introducd into Georgia and South Carolina as early as the middle of the last century. It now covers the area from central New Jersey westward to central Kansas and southward to the Gulf of Mexico, but in much of this territory it is grown only in a very limited way.

Growing and harvesting. Lespedeza makes a growth of from 2 or 3 inches to 2 feet in height, and is especially adapted to the states along the Gulf of Mexico and the south Atlantic Coast. While doing best where the climate is warm and the growing season long, it will thrive under varying conditions. It is one of the valuable pasture plants of the Ozark country of southern Missouri and northern Arkansas, having gradually spread over the rougher sections.

Lespedeza is not generally sown, but is spread by various agencies, including birds and livestock. It may, however, be seeded to advantage. In seeding, spring sowing at the rate of 10 to 20 pounds of seed per acre is recommended. Fall seeding is safe only in the states farthest south. A combination of oats and lespedeza is quite common. Redtop and lespedeza do well together. Lespedeza and Bermuda grass constitute another combination. As a hay crop, lespedeza does not produce as heavily as many of the other and more largely grown legumes, yet in some sections it is quite important. When

FIG. 302. A field of peanuts; a single plant in foreground

cut for hay, it is harvested when the plants are in full bloom and is handled much as is alfalfa. If a seed crop be the prime object, harvesting should not take place until a large number of the seeds are ripe.

Chief value. The chief value of lespedeza is as a pasture crop, it being especially suited to the poorer soils, depleted by cotton growing, in the South. It also thrives well in the mountainous districts, where timber growth is considerable and soil is thin and rocky. Lespedeza contains less water than any other cultivated legume, so that curing for hay is not difficult. Hay yield is generally light, but feeding value is high. It is valuable as a soil builder. (W. L. N.)

LUPINE. The most valuable cultivated species of this legume are annuals and are, with few exceptions, native to the Mediterranean region. However, in the United States, many varieties are common to the western ranges, where sheep and cattle are grazed. The lupines thrive on thin, sandy, well-drained soil, where little else will grow; few, if any, varieties are adapted to limestone soils. The native American species are pastured, rather than cut for hay. Where seed is sown by drilling, the rate is 80 to 100 pounds per acre; if broadcasted, double this amount is required. (W. L. N.)

MEDICS. The medics, some 50 in number are members of a group or genus named by botanists Medicago, from which their common name is derived. Their most important representative is alfalfa. They were once thought to be adapted only to semiarid regions; now, alfalfa and possibly a few others of the species are grown throughout almost the entire United States. The medics, both annuals and perennials with cloverlike habits, are native in Europe, Africa, and Asia. The name "bur clover" is applied to 2 of the best-known. The hop, or black medic, and another, known as "snail clover," are being tried out in the United States. Excepting those mentioned, the medics are but little known in this country and are of very secondary agricultural importance. (W. L. N.)

FIG. 303. Shoot of bur clover. (see Medics)

PEANUTS. The peanut is a low-growing annual with vines more or less trailing, according to the variety. It differs from other cultivated legumes in that the fruit is matured underground. The flowers are small and yellow. After the blooms fall, the flower stems continue to grow until the ends are buried in the ground; there they enlarge, and from them the pod is formed. The Jumbo Runner is one of the best-known large varieties of peanuts, and the Little Spanish one of the widely-grown small ones. Other varieties are the Runner (variously known as the Virginia, Florida, or North Carolina Runner), Improved Spanish, and Valencia.

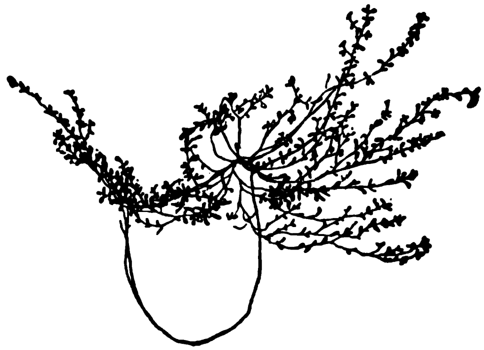


FIG. 304. Lespedeza plant, showing trailing, spreading type of growth where stand is thin; where thick it is more upright. (Farmers' Bulletin 441.)

Peanuts or "goobers" are grown commercially in Virginia, Tennessee, Texas, Arkansas, Georgia, North Carolina, South Carolina, and, to some extent, in a few other states. Smithfield, Virginia, is the centre of an extensive peanut-producing section, and Norfolk, in the same state, is a leading market.

Growing. A compact clay soil is not conducive to a high yield of peanuts. The soil should be loose, so as to allow for free penetration of the bloom pegs, the nuts forming under the ground. In favorable soil, properly tilled, it is not necessary to cover the blossoms by hand, as many beginners believe. The best market nuts are produced in light-colored, sandy soils. Lime is desirable, and, when lacking in the soil, should be supplied. Where stable manure is used it should be well rotted. An excess of ammonia, as in fresh manure, will result in heavy top growth at the expense of nut yield. Planting is sometimes made on very slight ridges, in order to provide better drainage. The prevailing

practice is to use shelled nuts for planting, although some varieties, such as the Spanish, may be planted in the hull.

The rate of seeding varies with the soil and the kind of peanut. Ordinary varieties require about 1 bushel of seed in hull or 8 to 10 quarts shelled to the acre. Of the larger varieties, 2 bushels of seed in the hull or 10 to 14 quarts shelled may be best. Large-spreading varieties, when planted early, are placed in rows 3½ to 4 feet apart with seed every 18 or 20 inches. When planted later, the distance apart in the rows is 12 to 16 inches. Of the smaller varieties, including the upright growers, seeds are usually planted 6 to 8 inches apart in rows 3 feet apart. Some, however, recommend planting seed in twos and only 8 or 10 inches apart. Thorough cultivation will pay.

Harvesting. Special peanut diggers, somewhat resembling potato diggers, are on the market. Plows, sometimes with moldboards removed, to prevent the covering of the plants with earth, are also used in digging. Many small growers use hand tools in harvesting. After the nuts have been removed from the ground, and the sand and earth shaken off, the crop is forked into rows, later to be stacked about stakes driven into the ground. Around these stakes are piled the vines with the nuts still clinging to them, placed near the middle. In a little while curing has taken place and the nuts are ready to be picked by hand or machines.

Yield and uses. In 1909, the production of peanuts in the United States was 19,415,816 bushels, an average yield of 22.3 bushels. The crop was valued at $18,271,929, the average price per bushel being 94 cents, and the average value per acre, $21. In 1909, the yield of peanuts in North Carolina was 30.6 bushels per acre; in Virginia, 29.5 bushels. Large quantities of peanuts are roasted and sold. Peanut butter and oil are also important food products. As feed for stock, both the nuts and the vines are valuable, peanut hay being much in demand. Where nuts are grown primarily as feed for stock, hogs are sometimes turned into the fields, to save labor. (W. L. N.)

FIG. 305. Peanut plant showing fruit ("nuts") and nodules on roots.

PEAS. The pea is an annual plant and is often grown for its seed, although in some cases it is grown as a forage crop for pasture or hay or for the silo and occasionally as a soil renovator. The crop is most generally grown along the northern border of the United States and in Canada. It cannot

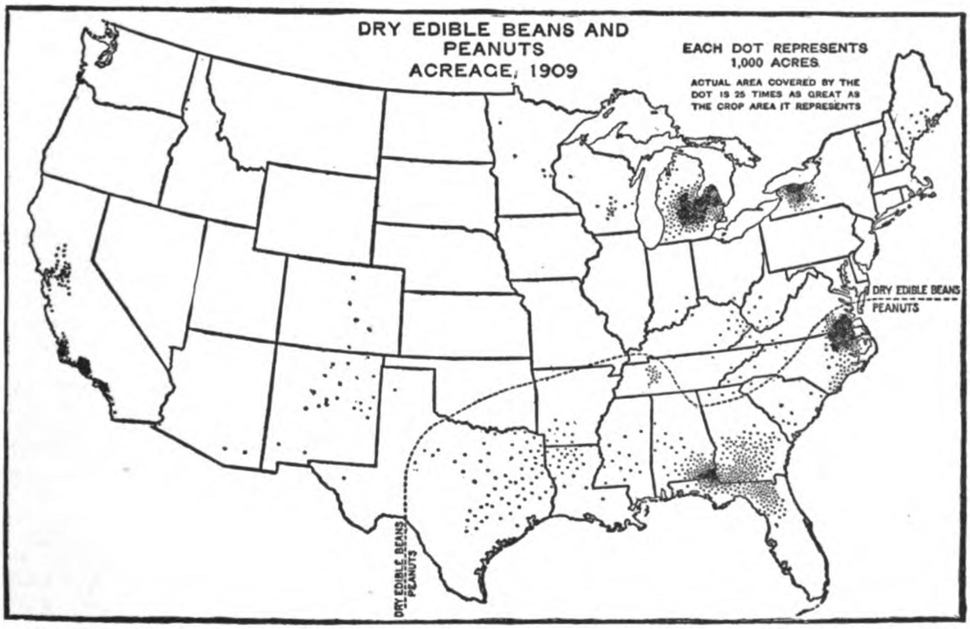


FIG. 306. This map considers only the acreages of beans and peanuts which are harvested when ripe. All legumes, but especially peanuts, are being more and more widely grown for hay and green forage. (1915 Yearbook, U. S. Dept. of Agr.)

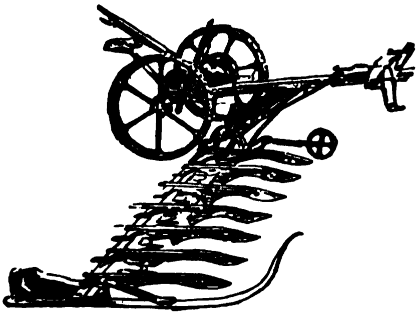


FIG. 307. Mowing machine fitted with pea vine lifter which insures getting the whole crop

stand hot weather. A large portion of the Canadian crop is grown for the purpose of feeding livestock, pea meal being a favorite concentrated feed.

Growing. The crop is grown on a variety of soils, loams and clay loams being better than lighter lands, as they are not so apt to dry out and become hot. The land is usually fall-plowed, so that the peas may be sown early. Thorough preparation is given, and if the land is deficient in lime it is applied at the rate of 1 ton to the acre; some fertilizer may be sown in addition. From 2 to 4 bushels of seed per acre are sown, according to the condition of the land and the variety of pea. The seed is planted deep, sometimes 3 inches, being sown with the grain drill. The crop is often sown on sod land and is followed by a crop of wheat or some other grain.

Harvesting. The crop is usually mown with a mowing machine, but a pea harvester, resembling the ordinary binder, but which does not tie the crop, is also used. The ordinary reaper, too, is sometimes used in harvesting. The seed is allowed to dry out in the bundles. Peas are threshed with the regular bean thresher. The grain thresher, provided with blunt concaves and run at a low speed, is also used. The mature peas may be fed to sheep without threshing; they will eat both the vines and the peas. Vines are also fed to hogs. For most other stock the crop should be threshed and the peas ground.

Peas are sometimes attacked by aphids. It is not feasible to control these by spraying. As they develop in a section the industry moves out. Mustard, which frequently grows in the crop, can be controlled by spraying with copper sulphate, 5 pounds of copper sulphate to 50 gallons of water, or 100 pounds iron sulphate to 50 gallons of water, as soon as the mustard plants are well up.

Varieties and uses. Among the common varieties of peas is the one usually known as the Canada pea; others are Prussian Blue, Golden Vine, Marrowfat, White Wonder, Canadian Beauty, and Mummy. Mummy peas are sold as dried peas and the Canada pea has usually furnished the split pea of commerce. When peas are sown for hay, some grass crop is usually sown with them, thus peas and oats, or peas and barley. The two mature about the same time and are threshed, then either ground together or separated by running over a screen. They may also be cut green and made into hay. They make, too. a very good soiling crop for cattle or sheep. (S. F.)

SAINFOIN. Although introduced into the United States more than a century ago, sainfoin is but little grown in this country. It is well adapted to pasturing, and as a hay crop ranks below clover and alfalfa. Long-lived and deep-rooted, sainfoin does well on dry, barren lands where neither clover nor alfalfa will grow, but is quickly killed out on wet lands. In some respects it resembles both clover and alfalfa; the stems, however, 1½ to 2½ feet in height, are inclined to grow erect, and leaves are borne at or near the base.

Most sainfoin seed on the market is sold in the pods. In this form it is sown, preferably in May or June, at the rate of 4 or 5 bushels per acre. Harvesting is much the same as for red clover. (W. L. N.)

SERRADELLA. Serradella is an annual from 6 to 18 inches in height and valuable as a forage and green manure plant. While it thrives in light, sandy soil and in regions of limited rainfall, it is less drought-resistant than some of the other legumes, nor will it withstand very much cold. Growth after the coming of warm weather is rapid, but until then is somewhat slow. Spring sowing, either alone or with a nurse crop, is recommended. Seeding is at the rate of 40 or 50 pounds per acre. Serradella is relished by cattle and sheep, but as a hay crop is inferior to both clover and alfalfa. (W. L. N.)

SOY BEAN. The soy bean (sojabean, or soyabean) is a native of the Orient and an important crop in China and Japan. During the past 25 years it has gradually gained favor in the United States, and is now recognized as one of our most useful crops. It will grow over a wide scope of country and does well north of the cowpea area. Soy beans are soil builders, and can be grown in many ways, and in practically all soils except the heavy, sour clays. They may be grown alone for seed or for hay or for a combined crop, in corn for silage, or for feeding off with sheep or hogs, or they may be grown on worn-out fields and plowed under for green manure. They add nitrogen to the soil in which they

FIG. 308. Peanuts stacked for curing on a Southern farm

grow, provided there is proper inoculation. As a feed, the soy bean is rich in protein, the most expensive food element. Combined with corn, the soy bean makes a well-balanced feed that nourishes all the body in the right proportion. Soy-bean meal is equal to cotton seed as a feed for cattle. It is said that a ton of soy bean hay fed on the ground will return about as much nitrogen to the soil as would 4 tons of average barnyard manure.

Varieties, seeding, and harvesting. The desirability of the different varieties of soy beans differs greatly under different conditions. In a test made by the Ohio Agricultural Experiment Station, the highest 5 yielders in order of their rank were Ohio 9016, Ohio 7496, Elton, Ito San 17268, and Shingto. The lowest five yielders, in a large list, were Sable, Cloud, Yosho, Mikado, and Taha. In other parts of the country some of the low yielders in Ohio have proved among the best. S. M. Jordan, a Missouri authority, recommends the Jet, Medium Yellow, and Mammoth Yellow for silage. The Mongol, he states, is the heaviest seeder, with the Mikado next. The Peking and Sable are also good and do well in poor soils. The Ito San is spoken of as a good early sort. For New York, Hollybrook Early, Medium Early Green, and Medium Early Black have been recommended.


FIG. 309. Soy bean plant showing pods and root nodules. (Farmers' Bulletin 372.)

The amount of seed required depends upon the variety and the method of planting. Seeds of some varieties, such as the Peking, are so small that when planted in corn, 3 seeds to the hill, a bushel will be sufficient for about 30 acres. Planted in the same way, a bushel of Mammoth Yellow will be enough for 12 to 14 acres. Planted alone in rows, a bushel will, on an average, plant from 2 to 5 acres, depending of course upon the distance between the rows. Drilled solidly, 1 bushel to the acre will be needed. Where grown for seed, a good plan is to plant in rows 30 inches apart with seed 1 or 2 inches apart in the row. This allows room for cultivation but a few harrowings are generally sufficient. Soy beans should never be cultivated when the vines are damp from rain or dew. For hay, soy beans may be drilled with a grain drill at the rate of 1 bushel per acre.

In making hay, a good time to harvest soy beans is when the pods begin to turn yellow or the lower leaves begin to fall. Where the object is to save the largest amount of seed, the pods should be further matured, but not so ripe that the seed will shatter. The old-time self-rake reaper is excellent for harvesting soy beans. One of the best implements for cutting is a mowing machine with side-delivery attachment. They may also be cut with a binder and cured in the sheaf. The yield of hay depends upon many conditions and may vary from ½ to 4 or 5 tons per acre. The seed yield depends upon soil, season, and variety and varies from 5 to 25 bushels per acre. In threshing, an ordinary grain thresher may be used, but this cracks many of the beans so that a special pea or bean separator is desirable when the size of the crop justifies its use. Small crops are sometimes flailed out. Where it is possible to turn sheep or hogs into the fields, this is the cheapest and most satisfactory harvesting method. (W. L. N.)

SWEET CLOVER. Sweet cover is commonly a biennial, although some species are annuals. In the Mediterranean region it has long been grown for forage and for green manuring. In America, except in limited districts, it has until recently been regarded as an undesirable weed. Now, many value it highly as a feed for practically all classes of livestock. However, owing to the woody growth of the plant as it nears maturity and to its bitter taste, some difficulty is often experienced in getting stock to eat it.

A thoroughly firmed seedbed is of even greater importance for sweet clover than for alfalfa. Inoculation is recommended, but is not always necessary. Seeding of hulled seed, sown in spring or fall, is at the rate of 8 to 30 pounds per acre, more of unhulled seed. From 12 to 15 pounds of choice seed should be sufficient where the ground is in good condition.

Sweet clover is frequently seeded with oats or some other nurse crop. Seed may be broadcasted on growing wheat when the ground is in a honeycombed condition in the

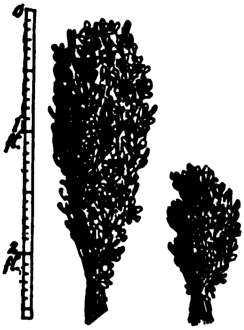


FIG. 310. Average growths of sweet clover on inoculated (*left*) and uninoculated (*right*) soils. (Farmers' Bulletin 797.)

early spring, or seeding may be delayed until the ground is dry enough to follow with a light harrow. Sweet clover is valuable as pasturage, whether grown alone or in a mixture, and for hay. Used as hay, it should be cut before the appearance of the flower buds. It is also important that the first crop of the second year be cut high enough so that a new growth will develop. With plants that have reached a height of 3 feet or more it is best to leave the stubble 10 or 12 inches high. Harvesting and threshing of sweet clover is the same as for alfalfa. (W. L. N.)

VELVET BEANS. Introduced into the United States as an ornamental plant about half a century ago, the velvet bean has during the last few years grown in favor as one of the important leguminous plants of the Southern states and especially along the Gulf Coast. While making a fairly satisfactory growth as far north as Missouri, it is in climates where it has a long growing season that the bean makes its best showing. The vine, valuable as a cover crop and for green manuring, frequently attains a growth of 50 to 75 feet. The plant takes its name from the dark velvety hairs which cover the seed pods. These pods are about 3 inches in length, and in shape are blunt rather than pointed. Both flowers and leaves are large. Planting practice calls for rows about 4 feet apart with plants 2 or 3 feet apart in rows. While the plants are small they should be given 2 or 3 cultivations. Later, as the vines spread, they crowd out troublesome weeds and also make further cultivation impossible. Harvesting is difficult, so that many growers utilize the crop by turning stock into the fields. As feed for cattle, hogs, and other stock, the velvet bean is excellent, both beans and hay being rich in protein.

Under favorable conditions, an acre of velvet beans will yield 3 or 4 tons of dry hay, but considerable difficulty is often experienced in curing. The yield of shelled beans may reach 30 or 40 bushels. A common method is to plant velvet beans, with corn, dropping beans between each second row. With this combination the prevailing practice is to utilize the crop by turning hogs into the field. Where corn is cut or husked, the bean

FIG. 311. Sweet clover, *a* 6-weeks growth; *b* at end of first season; *c* at end of second season; *d* branch of white sweet clover showing blossoms. (Farmers' Bulletins 485 and 797.)

vines add to the labor. In some cases, though this plan is followed and after most of the beans have been saved for seed and the corn removed, stock is turned in. As a soil renovator, especially when fed back on the land where grown, the velvet bean has no superior in the sections to which it is best adapted. (W. L. N.)

VETCHES. The vetch is a leguminous plant, generally of low, trailing habit, the slender branches being from 2 to 5 feet in length. The principal growth is made during the cool months. As grown in the South, the common vetch is an annual. The wild vetch, of which several varieties are found in the United States, is commonly known as the wild pea. Vetch is extensively grown in Europe, but not so in the United States, where the crop assumes most importance in the south Atlantic states and in Oregon and Washington. Where once established, the plant is sometimes inclined to persist as a weed. In wheat-growing sections this is objectionable. There are many kinds of vetch, but only a few are cultivated to any extent in the United States. Among these, are the so-called "native," or narrow-leaved, which really is not native to America but was introduced from Europe; the common or smooth, which is known also as spring tare; and the hairy, sand, Russian, or winter vetch.

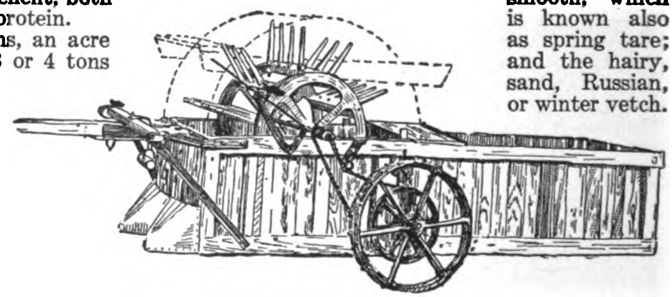


FIG. 312. One type of soy bean harvester. It is 11 feet long, 39 inches wide, weighs 800 pounds and costs about $100. Dotted lines show position of hood that covers the beating aparatus. (Photo S. R. Winters, N. Carolina.)

FIG. 313. Parts of velvet bean plant showing stem, leaves, flowers, and pods. (Farmers' Bulletin 102.)

The native, which makes rather erect growth, is frequently found growing wild in fields or along roadsides. The common vetch resembles the narrow-leaved, but grows larger and does not shed its seed so easily. Hairy vetch, a superior variety, takes its name from the dense growth of gray "hairs" which cover it. It is quite hardy, and, when sown in the spring, acts as a biennial. Its flowers are blue violet, the clusters being borne on one side. The seed-pods shatter easily. Seeds are small and almost black. Vetch is valuable as a pasture crop, as a hay crop, for soiling as a green manure crop, and, like all legumes, as a soil renovator. It also has a wider range of growth than most legumes.

Growing and harvesting. Vetch succeeds on almost any well-drained soil, but does best where limestone is abundant. Satisfactory crops are grown on sandy soil, to which hairy vetch is especially suited. It is a cool-weather plant or, in the South, a winter plant. Sown in August, September, or October, it may be drilled or broadcasted, but drilling is best. For common varieties, seeding should be at the rate of 40 to 60 pounds per acre, and 15 to 25 pounds of hairy vetch with a half seeding of oats or rape as a nurse crop. Frequently the usual amounts of oats, clover, and grass seed are used, adding 6 to 20 pounds of vetch seed per acre. Oats of a stiff-strawed variety are preferred, so as to provide support for the vetch. Inoculation is recommended. In the absence of inoculation, the best crop is seldom realized until the second year. Where the crop is to reseed itself, it should not be pastured too closely in early spring. In cutting vetch for seed, it is impossible to do so at a time when all the seeds are ripe. The best that can be done is to harvest when most of them are ready. This is when the lower pods are fully ripe and when seeds in the upper ones are forming. When vetch is cut late for seed, it does not equal in feeding value the crop saved earlier for hay. After the crop is cut it should be handled as little as possible to prevent shattering of the seed. In percentage of digestible protein, vetch ranks with alfalfa. The crop has not been as extensively grown in the United States as its value warrants. This has been due, in large part, to the high price of European seed. Now, however, considerable seed is being produced in the United States. The Willamette Valley, Oregon, is a leading seed-producing centre.

Advantages. The advantages of vetch are as follows: (1) It fits well into various short rotations. (2) It greatly enriches the land in nitrogen in a short time. (3) It is relatively inexpensive to grow, because the seed can be produced by the grower. One must, however, guard the purity of the seed carefully. (4) It is reliable as to stand and hardiness, if sown early and the autumn is not too dry. (5) It is a splendid winter cover crop where conditions are favorable to a strong autumn growth, but makes less increase in winter than is desirable. (6) It is a nutritious stock food and can be fed green, made into hay, or placed in the silo with other crops. (7) It prevents surface washing and gullying, but, on account of its relatively weak growth, certain other crops may be superior in this respect. (8) It is adapted to soils ranging from sandy to clayey in texture. (9) Seed is profitable in itself, for it may be used as a money crop, and the residue enriches the soil in organic matter and nitrogen. (10) It is a good spring pasture crop in many cases, although when green, it is sometimes not at first relished by stock. (11) It will reseed itself to great advantage in certain systems of cropping. (S. F.)

FIG. 314. Hairy vetch plant and (a) single shoot.

F. MISCELLANEOUS FIELD CROPS

By SAMUEL FRASER *and* WILLIAM L. NELSON *both of whom have raised with their own hands many of the crops discussed, and have told and shown other farmers how to improve their methods. Mr. Fraser is author of "The Potato," the first of the modern, authoritative textbooks on the subject. Mr. Nelson has written or edited many of the sound, practical farm bulletins issued by the Missouri State Board of Agriculture.*—EDITOR.

THE remaining important fieldgrown crops are mostly unrelated to one another, and differ in cultural needs and methods of use from all the other groups discussed in this chapter. It seems logical, therefore, to bring them together into a final group, arranged alphabetically. This relatively subordinate position is no measure of their importance either as farm materials or as food products. The potato (discussed also as a garden crop on p. 386) is, of course, one of the world's greatest staples; tobacco, though restricted in acreage, represents heavy investments along both production and manufacturing lines; onions (see p. 384 for garden culture) are a widely grown and profitable field or truck crop in many sections; and so on. There has been no special attempt made to treat these plants with regard to their botanical relations, except where this is of special interest or has a particular bearing on their management. The idea is to treat them as farm crops, from the farm point of view, giving such information as the farmer requires and can make best use of.

BEANS, FIELD. In this article we take up only those beans which are grown commercially as field crops in this country. Garden beans are discussed elsewhere, but it must not be understood that garden beans and field beans constitute distinctly separate groups. The Broad bean, valued as food for man and beast in Europe and Canada, makes a strong, erect growth of from 2 to 4 feet. It requires a cool summer, and, consequently, is but little grown in the United States.

Soil and climate. The expression "too poor to grow beans" has probably led to the impression that beans do best in a very poor soil. This, however, is not true. While the bean plant will grow in poor ground, it does best in soils that are fairly fertile. Clay loams, if well drained, and sandy loams rich in humus, are both good. Like most legumes, beans like a limestone soil. Until recently the region in which field beans are most extensively grown in the United States is chiefly within the area covered by the glacial drift, where strong soils are the rule. To-day, California, and especially the southern part, leads all other regions in production. Good drainage is important. In the states where beans are most largely grown, the summers are not extremely hot, nor do severe droughts commonly occur. This well illustrates the climatic requirements. However, insect pests and diseases are important limiting factors in commercial bean growing farther south. This is especially true of the bean weevil.

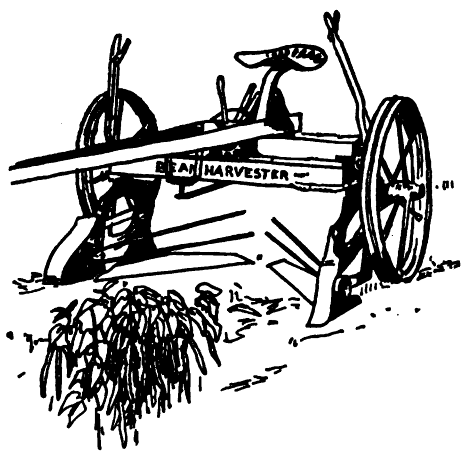


FIG. 315. Bean Harvester. Note the rods that support the plants and the knives that cut them off

Planting. The field bean should not be planted until all danger from frost is past. The ground should, however, be plowed as early in the spring as possible and should be given frequent harrowings until time for planting. In New York and Michigan, this will probably be from May 15 to June 20 for an average year. An ideal seedbed is fine and mellow near the surface but rather firm underneath. The ground should be warm when the seed goes into it, so as to secure quick germination and an even stand, as this will tend to result in even ripening of the crop. Late-planted crops are also more apt to escape bean rust. It is important, however, once soil and climatic conditions are right, not to delay planting too

long. The rate of planting varies, depending much upon the variety of the beans. Of small pea beans a half bushel of seed may be sufficient to plant an acre, while of red kidney beans, planted in the ordinary way, more than twice this amount may be required. In a general way, it may be said that in planting beans of the smaller varieties ½ to 1 bushel per acre is the rule, while for kidney beans the quantity varies from 1 to 1½ bushels per acre.

In field planting, the distance between the rows varies from 28 to 36 inches, with 30 to 32 inches the rather common practice. Special bean planters are available; but ordinary grain drills with some of the seed spouts closed, so as to provide for proper spacing of rows, are used. Seeds are dropped 2 to 4 inches apart in the rows, although ideal spacing with a perfect stand would probably be 6 inches. The depth of planting depends upon the kind of soil and its conditions regarding heat and moisture. In heavy soils, especially early in the season, planting should be shallow. In light soils planting may be 1 or 2 inches deep. An average depth, all things considered, would probably be about 1½ inches.

Seed should be free from disease, well developed, fully matured, and of strong vitality. It is a good plan to conduct a germination test before planting.

Varieties. There are many varieties of field beans. The Pea or Navy Bean, Mediums, Marrows, Kidneys and Yellow Eye for the northern belt of states; the Pinto for Colorado and New Mexico; the Small and Large White, the latter really a Medium, for California, are largely grown.

Cultivation. It is advisable to harrow the soil lightly before the beans appear, but care must be taken not to injure the plants just as they are coming through. As soon as possible after the beans are up, cultivation by means of surface plows, spring-tooth or narrow-tooth cultivator should follow. Frequent shallow cultivations should be made, especially after each rain. It is desirable to have most of the cultivation done early in the growing season, so that little will be required after the blossoming stage is reached. In growing beans a certain amount of hand hoeing may be necessary, especially during a season when weeds make unusual growth.

Harvesting and threshing. Where grown in a small way, or where machinery is lacking, beans may be pulled by hand. However, for large crops it will generally pay to use a bean harvester. This machine consists of 2 long steel blades, wide enough apart in front to cover 2 rows, but coming close together in the rear. These blades, above which are "fingers" to lift the vines, are mounted on a framework carried on 2 wheels. This machine cuts 2 rows of beans at a time and throws them into a single windrow. The vines are then bunched by men working with pitchforks, or a side-delivery rake is used. The curing process in the field is carried far enough so that the vines will not mold when they are stored prior to threshing. This is more often seen with Soy beans or cowpeas than field beans. When the beans are to remain in the field some time, they are frequently stacked in small cocks, being piled around stakes 4 or 5 feet high driven into the ground. Beans should at all times be kept clean and should be stored with as little weathering as possible. Care is also necessary to prevent shelling.

The ordinary grain separator or threshing machine, even when special arrangements are provided, is apt to result in many broken or split beans. However, specially constructed threshers are now available. These are really double threshing machines, one cylinder being operated at a low speed and the other at a very much higher one. The old-fashioned flail is also still used by some growers, but threshing by this method is slow and expensive.

FIG. 316. Beans stacked for curing

After the beans have been threshed, they must be carefully cleaned, so as to remove all discolored or broken beans, besides gravel, dirt, and other foreign substances. Most of the work of finally preparing the crop for market is in the hands of large dealers, whose plants are specially equipped for the purpose. Where beans are extensively grown, most of the marketing is through bean growers' associations.

Production and prices. In 1909, according to the Thirteenth Census, 802,991 acres of field beans were grown in the United States. The yield was 11,251,160 bushels, valued at $21,771,482. States leading in production were Michigan, 5,282,511 bushels; California, 3,328,218 bushels, and New York, 1,681,506 bushels. Previous to the outbreak of the European War in 1914, bean producers received from $1.75 to $2.50 per bushel, but prices went to $8 or more in 1917. In 1917, California alone produced nine million bushels, mostly Small and Large Whites, with some Pinto, Cranberry and other varieties. The Pacific and Mountain States entered the field, Colorado planting 200,000 acres, largely Pintos. Michigan produced 4,000,000 bushels on 650,000 acres and New York 1,000,000 bushels on 200,000 acres, both states showing crop failures owing to poor weather. (S. F.)

CABBAGES and KALE. Under this heading we may treat those plants of the cabbage family which form a head, as cabbage, and those which do not form a head, as kale. They are both from a common ancestry. The cabbages are grown in the northern climates or in the cool months of the year in the

South. The kales suit the mild and warm climates; thus in the South, the collards are kales. All belong to the mustard family, and are allied to turnips. Their place is as an intertilled crop and they usually precede a grain crop. They are used as food for man and for livestock, principally cattle and sheep. In some cases they are pastured off.

Climate and Soil. The main cabbage-growing area of the United States extends from Wisconsin eastward in the northern states, but there is considerable opportunity for extension in the far northwestern states, the climate there being ideal for the crop. Thousand-headed cabbage or kale is also grown to a considerable extent in the latter area. The best soil is one rich in organic matter. Crops are grown on all types from light loams to heavy soils. At least 20 tons per acre should be secured to warrant production. Under the most favorable conditions, however, higher yields are secured.

How to grow the crop. The soil should be well prepared by deep fall plowing, and an application of 10 to 20 tons of manure per acre and, if not in the best condition, a half ton of fertilizer of high-grade mixed goods and an application of 1,000 to 2,000 pounds of lime per acre is often advisable. The land should be put in the best physical condition, and the seedbed should be loose, friable, and well prepared. In the case of cabbage, the seed may be sown in beds and transplanted, or it may be sown in the field where the crop is to be grown. If sown in a permanent place, allow 1 pound of seed per acre; in beds for transplanting, from one half to 1 pound. The plants should be thinned as soon as they have 3 or 4 leaves. Transplanting is usually done as soon as the plants are 7 or 8 inches tall. On a small area the plants may be put in by hand. A man, with a spade to open the trench, and a boy, to drop the plant, will do the work quickly, the plant being placed back of the spade before the latter is withdrawn, and firmed with the foot, after it is in place. On larger acreages the transplanter, drawn by 2 horses and fed by 2 boys, is used. With this 17,000 to 20,000 plants per day may be set. The trench is opened, a jet of water is thrown on the roots of the plant as it is released, and the roots are covered. The boys alternate in feeding the plants, one reaching for a plant while the other puts it in place, the plants being carried in front of them. These machines are used also for planting tomatoes, tobacco, and other crops.

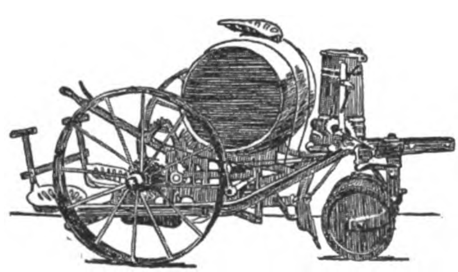


FIG. 317. Transplanting machine for handling cabbage, tobacco, etc. It requires two horses, a man, and two boys, but saves much time and labor.

The early sowing of seed is advised, usually early in May; this insures a larger yield. The rows are commonly 30 to 36 inches apart, and the plants about 2 feet apart in the row, the distance, however, depending somewhat on the variety. They are given constant cultivation until the plants meet. It is usually advisable 3 or 4 days after planting to apply 100 pounds of nitrate of soda per acre. This may be applied with a fertilizer barrow.

The plants are usually harvested as needed, or they may be harvested and piled and covered with straw or afforded necessary protection, so that they will be available for a longer period. Where the crop is grown for market, they may be stored in cellars. Varieties such as Danish Ballhead, are used for sale purposes because they will keep, but where the chief use is for cattle feeding, those which produce the highest amount of feed value, as Drumhead, Surehead, and Autumn King, are grown.

Thousand-headed cabbage is usually sown in rows about 30 inches apart and at the rate of 4 pounds of seed per acre. The plants are thinned to 12 to 18 inches apart. They are either pastured off or cut and hauled to the feeding yards. Dwarf Essex rape is also handled in somewhat similar manner or is sown broadcast.

The total yield is not the sole factor to be considered. The important thing is to grow dry matter. This varies with the season and the variety. The percentage of dry matter will vary from 5.75 to 9.5 per cent, even in the same variety, in different years. The yield of dry matter per acre varies from 1½ to 2½ tons, and has a feed value comparable with the dry matter of cereals. (S. F.)

CACTUS. The cactus is a queer-looking, generally spiny plant found growing wild in Arizona, New Mexico, and other parts of the southwestern United States. Not all such appearing plants, however, are true cacti. The species found growing in New Mexico are those which either can do with very little water or can endure severe winter temperatures. The cactus, because of its shape, the character of its covering or "skin," the thickened stem with its large moisture-storage capacity, and a root system peculiar to many arid plants, is able to collect and retain moisture to an unusual degree. With these advantages and with the spines affording protection from attacks of hungry and thirsty animals, cacti thrive as could few plants under similar conditions. It must be understood, however, that cacti must have some water in order to live and grow.

Cacti are used as a stock feed. This fact has been given much publicity through the exploitation of the so-called spineless varieties. The species of cacti most used as stock feed are those known to Americans as "prickly pears." Some of these have but few large spines or thorns, yet are able to withstand adverse conditions which some much-advertised cultivated species have been unable to endure. Cactus joints which are to be planted should be kept in a dry, sunny place for a week or more or until the cut surfaces have callused.

Cacti do well in locations not suited to grass. "As an inexpensive reserve supply of food stored against a season of drought," says New Mexico Agricultural Experiment Station *Bulletin* No. 78, "there is nothing now known which can compete with cactus in the arid Southwest, since it slowly accumulates during the favorable seasons and is ready to be called upon when the unfavorable one comes." (W. L. N.)

CASTOR BEAN. The castor bean, as we know it in the United States, is an annual plant which in height compares with corn, but in the tropics it may make a tree 20 to 30 feet high. As grown in the Southwestern states of the corn belt, the seeds are planted in rows 4 or 5 feet apart, with hills 15 to 18 inches apart in the rows. Where several seeds are planted in one hill, it is best to thin to a single plant when they are 6 or 8 inches in height. Two to 4 quarts of seed are required to plant an acre. Cultivation is much the same as for corn and is continued until the plants have reached a height of 2 feet or more. A sandy loam soil is excellent for castor beans, but they also do well on a fairly stiff clay or a light, sandy soil, such as is found in parts of Kansas and Oklahoma.

Planting is done in the spring after the ground has become fairly warm. The pods are gathered in late summer as they ripen, the rule being to gather them as soon as they turn brown, to prevent the beans being lost. All the pods do not ripen at once, so that harvesting may continue for several weeks. The ripened clusters are cut off and thrown into a wagon having a tight box, after which they are hauled in and spread on the floor of a shed or barn to dry out. In drying, the pods burst, and most of the beans are in this way "threshed." Later, they are gathered up and passed through a fanning mill, in order to remove any trash.

Castor oil, valuable as medicine, as a lubricant, and in the dyeing of cotton, is derived from the castor bean. The bean is grown also in many gardens as an ornamental plant. There is also a belief that it will keep away moles. But few insects attack castor beans.

CHICORY. Chicory is a perennial plant the enlarged taproot of which is largely grown as an adulterant of, or substitute for, coffee. The roots range from several inches to 2 or 3

FIG. 318. Cactus supplies a nutritious and palatable forage crop for cattle

feet in length and from 1 to 3 inches in diameter. Chicory does best on a loamy soil that is free from stones or hardpan near the surface, but it can be grown on almost any good land in the north-central portion of the United States. From 1 to 1½ pounds of seed will be sufficient to plant an acre of ground, but care should be taken not to plant too deep. Cultivation, generally, is much the same as for sugar beets. Owing largely to the uncertainty of manufacturing the crop into a finished product, chicory has not been extensively grown in the United States. Most of the chicory used here comes from Europe. (W. L. N.)

HOPS. The hop vine is a perennial which often makes a growth of 25 to 30 feet in a season. It is rough and "hairy," and the stems have little prickles pointing downward. The fruit or flower, often spoken of as "the hops," is paperlike, straw-yellow, and often 2 inches or more in length. It bears a peculiarly pungent substance which somewhat resembles resin and is known as lupulin. It is this that gives the bitter taste to beer, in the brewing of which hops are largely used. Although grown almost the world over, hops are cultivated in the United States mainly in Oregon, Washington, California, and New York. The wild hop, however, is found in many other states.

How grown. Hops will grow in many kinds of soils, from fertile valley lands to poor hillsides; but the most rapid growth is made on rich, sandy loam which, while well drained, is amply supplied with moisture. Applications of stable manure or commercial fertilizers give good results, except in "new ground" where plant food is plentiful. The hop vine withstands drought better than do most other plants. In hops, pistillate and staminate flowers are not borne on the same plant. The seeds are few, as many flowers do not produce them.

Propagation is by the planting of cuttings. These cuttings, which consist of underground stems, or "roots," are secured by grubbing up runners from established hills and cutting them into pieces 5 to 10 inches in length. When ready to transplant, these cuttings are set in hills 6 to 8 feet apart, with 2 to 4 pieces in a hill. Except in California and in other places where the climate is such

FIG. 319. The weeding of onions, especially while they are small, is a task that can be done only by hand

that plantings can be made in January and February, the hop yields no crop the first season. In order, therefore, to get some return from the land during the first year, corn is sometimes planted, alternating with hops. Pruning or "grubbing" is frequently required, the first such work generally being done after the plants have been set out about a year. Cultural methods differ. Ordinarily, shallow cultivation is given as often as is necessary to keep down the weeds. Training is important. Poles, from 20 to 25 feet in length, are set in the ground, and on each of these a number of vines are trained. The trellis system is also used.

Harvesting and curing. Hops are picked when the hop feels solid and has somewhat of a papery appearance and when some of the seeds have become brown and solid. Picking, which largely represents the work of women and girls, usually begins in the latter part of August and is completed before the end of September. In drying, hops are placed in a dryhouse provided with a heater or furnace. This house has a loft the floor of which is of lath; and over this floor is stretched a layer of some open-meshed cloth on which the hops are spread. The heat from below soon dries them. Some sulphur is burned, so as to give the desired color and also to act as a preservative. After being taken from the kilnhouse the hops are "sweated" in the cooler. They are then pressed into compact bales when they are ready for market. (W. L. N.)

ONIONS. Onion growing has become a well-established industry in many states. According to the Thirteenth Census, the states having the largest acreages in onions were: Ohio, 6,132; New York, 5,558; Texas, 5,170; California, 4,391; Indiana, 4,048; Illinois, 3,315; Louisiana, 2,909; Massachusetts, 2,493; Kentucky, 1,959; New Jersey, 1,417; Michigan, 1,130; and Minnesota, 1,099. There are numerous varieties and several types of onions. Some are best suited to Southern latitudes, while others are fitted to Northern localities. In considering onions as a field crop it is easiest to discuss them under two headings: (1) commercial onion growing in the North, and (2) commercial onion growing in the South.

The crop in the North. The soil is one of the most important factors entering into the successful production of onions. As a rule, growers prefer dark soils to those that are light in color. A good sandy, well-drained loam, liberally provided with plant food, is the best. Heavy, stiff clays are to be avoided. In Indiana, onions do especially well on the muck soils of the northern part of the state. Drainage should be good, and soil preparation thorough. Where onions are grown from seed, the surface of the field should be made very fine and smooth and as level as possible. None but seed of the best quality should be sown. As onions require a cool, moist season for their early development, the seed should be sown as early in the spring as the ground is in condition. Seed is usually sown with garden drills. Where the rows are 12 to 14 inches apart, 4 to 6 pounds will sow an acre. Cultivation should begin as soon as the rows of seedlings can be seen. Wheel hoes are largely used. Some hand weeding may also be required. Curing is effected either in the fields or in open sheds. In crops grown from seed, the bulbs do not always mature as early as is desired. In this case, maturity may be hastened by breaking down the tops, which may be done by rolling a light empty barrel over them. Many onion growers sow the seed in hotbeds, the onions being later transplanted in the fields.

The crop in the South. What has been said as to soil and preparation of seedbed applies to southern conditions as much as to conditions in northern states. One advantage that the South enjoys is the ability to market its crop early. Onions are grown principally from seed, yet some are transplanted from beds, and in some cases "sets" are used. However, the labor involved in the case of sets is a drawback. The Bermuda onion is largely grown in southern Texas. The seed of this onion is not successfully produced in the United States. In growing the Bermuda onion, seeds are usually sown in beds about October 15 and are ready to transplant early in December. The crops, where grown in the best of soil, should be ready for market in April or early in May. Bermuda onions are mild in flavor and command good prices.

Onion sets. The growing of onion sets, as the small bulbs which form on seedling onions

FIG. 320. Harvesting onions on drained muck soil in central New York. (U. S. Bureau of Soils.)

are called, can be carried on almost anywhere where commercial onions are grown successfully. In growing sets it is desirable to induce early maturity either by sowing thickly or by lack of plant food. In curing the sets free circulation of air is essential. The sets are sold principally to seed firms. (W. L. N.)

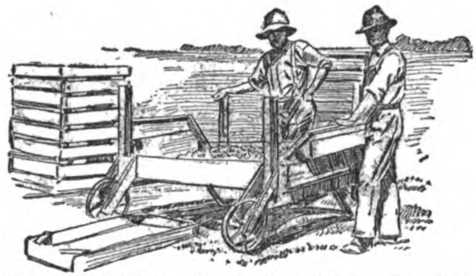


FIG. 321. Sorting and cleaning onion sets. (Ind. Circular 67)

Potatoes

The potato is a perennial plant in warm countries, like the tomato and eggplant to which it is related; as a farm crop, it occupies the ground for only one season. It was unknown to the old world until the discovery of America. It was then found under cultivation in Peru and growing wild in other places of high elevation and temperate climate. European nations soon recognized its value. At present the world's crop is more than 5 billion bushels, about equaling the rice crop and vastly exceeding the wheat crop. Under normal conditions, Europe produces about 90 per cent and Germany alone 30 per cent of this total. The top growth of the potato varies between 1 and 7 feet, averaging about 3 feet, according to the variety, soil, season, etc. In the wild plant, the tubers—which are really thickened sections of underground stems and *not* roots like sweet potatoes—are of no value. In the cultivated forms, they are enlarged and improved and represent one of the most important sources of starch both for food and for industrial purposes.

The potato forms about 25 per cent of the food of European and English-speaking peoples. In the Orient it is virtually uncultivated, largely because of unfavorable climatic conditions; however, rice supplies an entirely satisfactory substitute.

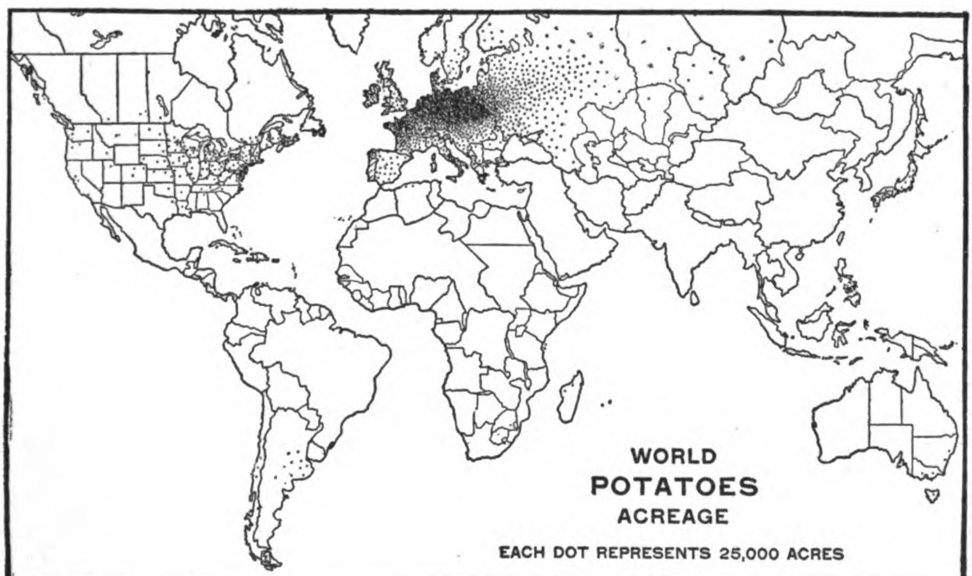


FIG. 322. The potato is a cool weather and moisture loving plant; except in a few sections it is a less important crop in America than in Europe. Strangely enough it is relatively of no importance in that part of South America where it was discovered. (1916 Yearbook, U. S. Dept. of Agr.)

Adaptations and Requirements

Climate. The potato has been developed to meet a great variety of conditions, and is now grown in almost every country of the temperate zone. A climate of cool nights and warm days seems most favorable to it. Periods of extreme heat, especially during August and September, are quite harmful to the vitality and vigor of the plant, which is at its most critical stage while forming blossoms and tubers; excessive heat at this time may ruin the crop. Good potato regions, therefore, are those in which frequent and considerable changes of temperature do not occur. A rainfall of 18 inches during the growing season is sufficient to insure a good crop; one of 14 or 15 inches, if carefully conserved, makes a fair yield possible.

Soil. A deep, mellow, free-working loam is considered best for potato culture. It may contain a slight amount of clay, provided it is well drained; but sandy and gravelly loams are preferred, because they can be prepared earlier in the spring, will warm up quickly and force early sprouting and rapid growth, and may be worked more easily and at less expense than heavy soils. Manures and fertilizers are usually more effective on them than on lighter soils; the potatoes themselves are usually brighter, more attractive in appearance, and usually of more uniform size and better quality than those grown on heavier land, since the lack of moisture commonly found in light soils toward the end of the season hastens their maturity. Moreover, potatoes grown on sandy loam will keep better than those grown on clay. Even along the Atlantic Coast, where early potatoes are a specialty and where a light soil is naturally necessary, there is a preference for sandy loams rather than the lightest sandy soils.

Place on the farm. The potato is purely a cash crop grown for sale, except, of course, in the case of the kitchen-garden crop raised for home consumption (p. 386). It is usually regarded as a cultivated or "cleaning" crop, generally following clover or grass and preceding grain. The fertilizing and careful and constant tillage it receives fit the land well for a succeeding grain crop. In most cases, it is not advisable to take 2 successive crops of potatoes from the same land or to have potatoes follow another tilled crop, unless the land is such that its texture cannot be injured by constant cultivation. It is often possible and desirable to grow a certain acreage in connection with other farm activities. In the North, for instance, it is grown as a main summer season crop on dairy or general farms, where it prepares the ground for grain crops and seeding, and is regarded as a semistaple, since it may be safely stored for several months. In the Southern states, it is grown as a winter, and very largely as a truck, crop; owing to difficulties of storing it, it must be handled as a half-perishable crop and is usually shipped north as soon as dug. In irrigated sections, it usually takes the place of corn in the rotation system, representing, with sugar beets, a main money crop.

Types and varieties. There are several thousand varieties of potatoes, but relatively few of importance in this country, and the aim is to reduce the number to a dozen. These may be roughly classified as "earlies" (70 to 90 days from planting to digging), "second earlies, or medium" (90 to 130 days), and late varieties (up to 200 days). The aim of potato breeders is to produce varieties yielding heavy crops of tubers of good flavor and quality, and having relatively short, upright tops, carrying an abundant supply of rot-resistant foliage which may be easily sprayed. Tops which sprawl on the ground are more liable to attacks of disease, because they hold moisture instead of drying off quickly; they are also more easily beaten down and damaged by winds and storms. Tuber shapes vary from round, flat-round, and oblong to kidney-shaped, but in the main crop varieties the endeavor is made to standardize either the flat-round or the oblong varieties; for it has been found that in these a smaller proportion of the tuber is occupied by pith, that is, the central portion low in starch content and therefore undesirable. In early varieties, round and kidney-shaped tubers are acceptable. Deep eyes are undesirable: although they are frequently associated with robustness and vigor, tubers bearing them are often coarse; also, the eyes cause waste in peeling, and tend to hold moisture in storage, hastening decay. The skin may be thick, medium, or thin, smooth or netted, and white or colored; the tuber may be white, pink, or blue-black. Vigor, blight resistance, and trueness to type or name are all-important characteristics. At present, potatoes are classified under eleven groups as follows:

EARLY VARIETIES

Cobbler. Shape roundish; color: of skin, creamy white; of sprouts, reddish violet; of flowers, light rose purple. Leading variety: *Irish Cobbler*.

Early Michigan. Shape oblong or elongate-flattened; color: of skin, white or creamy white; of sprouts, light rose purple; of flowers, white. Leading variety: *Early Michigan*.

Early Ohio. Shape round, oblong or ovoid; color: of skin, flesh-colored or light pink with raised russet dots; of sprouts, violet-lilac; of flowers, white. Leading varieties: *Early Ohio, Early Six Weeks, Late Ohio*.

Hebron. Shape long, flattened, or spindle-shaped; color: of skin, creamy white clouded with flesh color or light pink; of sprouts, white or rose-lilac; of flowers, white. Leading varieties: *Beauty of Hebron, White Elephant, Columbus*.

Rose. Early; shape roundish, oblong, long or spindle shaped—flattened; color: of skin, flesh-colored or pink (white in *White Rose*); of sprouts, white or rose lilac; of flowers, white or rose-lilac. Leading varieties: *Early Rose, Late Rose, Extra-early White Rose, Spaulding No. 4, New Idea, Old Early Rose*.

Triumph. Shape roundish; color: of skin, creamy white with red splashes; of sprouts, reddish violet; of flowers, bright rose purple. Leading varieties: *Triumph, Bliss's Triumph, Quick Lunch*.

MEDIUM VARIETIES

Burbank. Shape, long cylindrical to somewhat flattened, inclined to be slightly spindle-shaped; color: of skin, white and smooth or deep russet; of sprouts, white or rose lilac; of flowers, white. Leading varieties: white-skinned, *Pride of Multonomah, White Beauty;* Russet-skinned, *Netted Gem* (or *Russet Burbank*), *California Russet, Wonderful, Scabproof.*

Green Mountain. Shape oblong, usually broad and flattened; color: of skin, dull cream or light russet with russet-brown patches at seed end; of sprouts, white or rose-lilac; of flowers, white. Leading varieties: *Idaho, Rural, Gold Coin, Charles Downing, Carman No.* 1, *Green Mountain, Empire State, Rustproof.*

Pearl. Shape round, flattened, or heart-shape flattened and usually heavily shouldered; color: of skin, dull white, dull russet, or brownish white to deep bluish purple; of sprouts, light rose-purple; of flowers, white. Leading varieties: *Pearl, People's, Blue Victor.*

LATE VARIETIES

Peachblow. Shape round to round-flattened or round oblong; color: of skin, creamy white splashed with crimson or solid pink (red eyes); of sprouts, reddish violet; of flowers purple. Leading varieties: *Improved Peachblow (Red McClure), White Peachblow, Early Rainbow.*

Rural. Shape broadly round flattened to short oblong or oblong flattened; color: of skin, creamy white or deep russet; of sprouts, violet-purple; of flowers, white and purple. Leading varieties: *Rural New Yorker No.* 2, *Sir Walter Raleigh, Carman No.* 3, *Peerless, Russet.*

How to Grow Potatoes

Soil preparation. Begin this 2 or, preferably, 3 years ahead of planting; in other words, start with some other crop in the rotation and plan to have potatoes follow clover, alfalfa, or timothy sod as the third crop when the soil will be rich and in good tilth. In Maine, potatoes follow clover or grass; in Florida, cowpeas have proved valuable as a preparatory crop; in Ohio, a 3-course rotation of potatoes, wheat, and clover gives satisfaction for a time, but it is too short for permanence, potatoes occur too frequently; in Maryland, a crimson clover crop the year previous has been of value. In northern regions, plow in fall, if possible; otherwise, very early in the spring, according to local conditions.

In Europe, furrows 12 inches deep are common; in this country, 8 or 9 inches is deeper than the average. The high yields secured in Great Britain are the result of having the land thoroughly underdrained, heavily manured, and deeply plowed, and of constantly tilling it throughout the season; of practising regular and long rotations in which potatoes occur only once in 7 or 8 years; of favorable climatic conditions; and of exceptionally desirable varieties well adapted to local conditions. In preparing the land there, it is not uncommon to manure the sod the year before plowing, then to manure the land again when plowed; 10 tons per acre each time are frequently used. In addition, heavy applications of fertilizer are made, frequently from 600 to 1,000 pounds to the acre of a 4-20-8 or 3-17-14 mixture. Potatoes are planted 12 to 15 inches apart in rows 27 inches apart, given thorough and constant cultivation, and yield 700 up to 1,000 bushels per acre. This is ideal potato production, and such yields can be secured only after 2 or 3 generations of careful farming have brought the land into the right state of high fertility. Some of our eastern land, and some of the virgin land in the northwestern states awaiting irrigation and at suitable elevations, is probably ready to produce yields equal to those secured in Europe, for it offers both high fertility and the desirable climatic conditions.

Thorough stirring of the soil is essential in the eastern and central states. The application of 10 tons per acre of manure is advisable, also, under normal conditions, the application of from 500 to 1,000 pounds per acre of some good mixed fertilizer. The use of a ton or more (which is not uncommon on Long Island and in Maine) is probably not economical in most cases. The fertilizer may be either sown broadcast or drilled into the furrows at planting time; if the former, it should be thoroughly mixed with the soil. Whether to use nitrate of soda or sulphate of ammonia to supply nitrogen, is a question upon which good growers differ; in Europe, the sulphate is frequently preferred. To supply potash, either the sulphate or the muriate may be used. Acid phosphate is generally preferred as a source of phosphorus. It is not advisable to apply lime or wood ashes immediately before planting potatoes. If these are used, as must often be the case when mineral potash is unavailable, it is better to apply the lime to the land before the clover or sod crop, because it tends to produce scab.

Seed: selection, care, etc. Seed from northern regions is generally preferred, and the increased returns justify this preference. It is believed that the greater vigor and increased crop are due, in a large measure, to the fact that the northern-grown potatoes are not fully mature; their harvesting having been hastened, or, rather, they having been harvested before they were ripe, they have, therefore, greater growth force and vitality. In the central Atlantic states, second-crop potatoes similarly harvested before they are fully mature appear just as valuable for seed as those grown farther north. The best way to hold seed potatoes is in cold storage at a *constant* temperature of 33 to 35 degrees F.; a varying temperature is unsatisfactory. A cool, fairly dry cellar or roothouse is usually satisfactory, and in the North, large quantities of potatoes are held in pits. Here, of course, extreme cold is as much a danger as is heat farther south. In Maine and Wisconsin, therefore, the larger storage buildings are equipped with heating facilities. Frequently the manner of storing the seed potatoes decides their value. Potatoes stored in deep piles in cellars or bins frequently germinate unevenly, those from the bottom of the pile, although appearing healthy having lost their vitality.

If possible, spread the tubers thinly on a barn floor, 2 or 3 thick, and expose them to sunlight for 2 or 3 weeks before planting; this

stimulates germination and increases the yield. On the island of Jersey and in the early-potato regions of Europe, it is customary to store all seed potatoes in tiers of flat trays, each about 30 inches long, 20 inches wide, and 3 inches deep, with a 7-inch post in each corner to prevent the tray above from resting on the tubers. The advantages of these trays are (1) that the seed cannot heat, (2) a large quantity of seed may be stored in one room, and (3) the seed can be easily examined at any time. The potatoes may be sprouted and carried to the field in the trays, and planted directly from them. This involves hand work, but the results show that in this way the date of digging may be advanced 2 or 3 weeks, and that the yield may be increased. The reason for the increase is that the short, thick stems developed under the above conditions bear a great many scales or leaves in proportion to their length, and it is from the bud below each of these scales that the tuber-bearing branches are produced; thus the more scales produced, the greater the possibility for tuber development. If the shoot starts in the dark, either indoors or below ground, the scales are formed farther apart, fewer tuber-bearing branches develop, and the leaf-bearing branches produced above ground are weaker.

Prevention of scab. Several types of scab disease attack potatoes, reducing the yield and lowering the crop value. These live over in the soil on the roots of plants such as mangels and rutabagas or may be brought in by infected seed potatoes. The addition of lime, wood ashes, and manure to land tends to increase scab, while such fertilizers as acid phosphate, sulphate of ammonia, and muriate of potash tend to reduce it.

In some communities, growers have organized to produce and market "certified seed," that is, seed sold under a state certi-

FIG. 323. Select seed potatoes in the field, choosing medium-large tubers from heavy-yielding hills. Good and poor plants may grow side by side with no top characters to tell them apart. (Farmers' Bulletin 365).

ficate or seller's guarantee of freedom from disease, trueness to type, uniformity, quality, etc. Such seed naturally costs more than the average, but the results of its use are likely to more than balance this increase.

Size of seed pieces. Whether to plant potatoes whole or in pieces is a problem to be determined mainly from a financial standpoint. When seed is cheap, the labor of cutting may be greater than the extra cost of enough seed to plant whole tubers; when expensive, seed is best cut as small as possible. A potato if cut into single-eye pieces, will, if each piece be planted in a hill, go further and give a greater total yield than if planted whole. Early varieties and those with white blossoms will not stand cutting so well as later varieties and those with purple or colored blossoms. Again, some varieties have so few eyes that they cannot be cut to advantage. Generally speaking, the larger the seed piece, the greater the yield; the additional food supply in reach of the young plant insures a more vigorous start. Good-sized seed is especially desirable on light soils and in the case of early maturing varieties. Tubers or pieces weighing 2 or 3 ounces are the most profitable. Small potatoes from hills of high yield may safely be used; small ones that are the largest the plant produced or that come from a low-yielding hill should not be used. It is the character of the hill rather than of the tuber that we want to have inherited. Usually, it requires about 17 bushels to seed an acre; 12 is a common amount, but less than this is not economical when seed prices are normal, because of the extra cutting required. Usually, it is best to cut the seed only a few days before planting and to dust the pieces with sulphur or gypsum to prevent their rapid drying out and to keep them from sticking together in the planter.

It is important to guard against injury to the seed which may occur in a number of ways. For instance, if the potatoes heat after being cut, the eyes may fail to start. If they are treated for scab by dipping, it is important that they be either planted at once or spread out thinly to dry. Potatoes which have been frozen, even though not badly enough to destroy the tubers, may be worthless for seed; potatoes shipped in bags or barrels which have contained substances injurious to the eyes, such as nitrate of soda or sugar, are often rendered useless. Tubers that have been immersed in water for a day or more, that have been in pits which have been flooded or that have been soaked in a too strong formalin solution, may all be worthless for seed, even though the potatoes may appear to be sound.

Planting. Under normal conditions, potato roots will spread 2 to 2½ feet on each side of the plant; but, commercially, it does not pay to give them this much room. In Colorado, the rows are sometimes made 4 feet apart; but in the humid regions, they are usually 30 to 36 inches, and in some cases, 27 inches, depending upon the value of the land, price of labor, and the variety. Early varieties are usually planted more closely than later sorts, and those with short, upright-

growing tops closer together than those that sprawl. Early varieties should be put in rows 27 to 30 inches apart, with seed pieces 8 to 12 inches asunder; and later varieties in rows 30 to 33 inches apart, the plants 12 to 18 inches apart under eastern conditions.

The depth of planting varies with the soil and the climate. Under eastern and central conditions, about 4 inches deep is best; on heavy soils 2 inches is better, provided that the potatoes are prevented from getting sunburnt.

Planting dates naturally vary widely, beginning in Florida in December or January; the early potatoes of Virginia are usually planted during February and March, and the second crop about August 1. In central New York, the middle of May, and in Wisconsin, Maine, and parts of Canada, late in May, or even early in June, are suitable dates.

For small patches the usual method is to plant by hand in a furrow made with a common or shovel plow; manure or fertilizer is placed in the furrow; the seed pieces are dropped and then covered with the plow. Generally, the furrow should be made so that the tubers will be 4 inches below ground when the surface is leveled. Make the rows straight; plant the pieces in a single straight line, at uniform distances apart; and push them into place so that they will not move when the furrow is turned on them in covering. Where hand planting is done, and the tubers are not sprouted, hand planters somewhat like hand corn planters may be used; with one of these a man may plant an acre a day. Where as many as 8 or 10 acres are planted, a horse-drawn planter is advisable; this opens the furrow, distributes the fertilizer, and drops and covers the seed, planting from 3 to 6 acres per day.

Cultivation. Before the plants come up, harrow the field lightly two or three times; this will destroy a large number of small weeds. As soon as the plants appear, cultivate rather deeply, that is 4 inches, and as close to the rows as possible; 7 to 10 days later, cultivate again, but not quite so deep. Usually, 4 cultivations are given, the tendency being to push a little soil toward the plants each time. In some cases, a weeder is run across the rows as soon as the plants are up, to destroy any small weeds which may be between the plants, thus saving hand work; it may be safely used until the plants are 6 or 8 inches tall. The third and fourth cultivations should be shallow. Throughout the East, level tillage is preferred; for it has been found that, except upon very heavy soil, evaporation is less, the water supply is kept nearer the feeding roots, and increased production results. In some regions the land is mulched with straw or shavings instead of being cultivated, but, usually, this is too expensive.

Tubers form rapidly during the last 4 weeks of growth. In the northern states, during the month of September, the yield will frequently increase at the rate of 30 bushels per acre in a week; hence the importance of maintaining the plant in full vigor up to this date, so that the full benefit of its work may be secured.

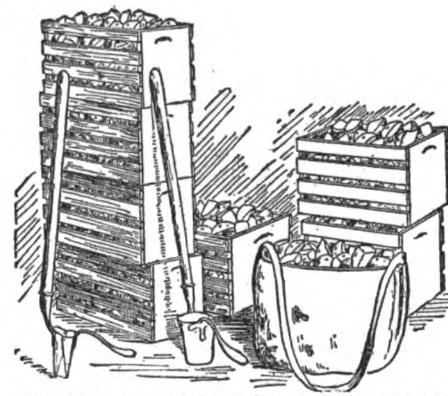


FIG. 324. An outfit for small-scale planting, consisting of two hand planting tools, a bag with sling support, and crates of cut seed. (Wis. Bulletin 280).

Irrigation. Where irrigation is practised, plan to have the young tubers set at the most favorable time of the growing season. Cultivate as usual and do not irrigate until plants are in flower; early irrigation causes shallow rooting. Do not flood the land; it keeps out air and packs the soil. According to the method described in Farmers' Bulletin No. 386, shallow trenches are made with a double-moldboard plow, and water is allowed to flow down every other trench until it begins to soak through into the dry furrow. This indicates that the roots have been sufficiently moistened, and further wetting will raise the water level too high and endanger the tuber bed. Cultivate as soon as possible after each irrigation, to lessen evaporation. In the second irrigation, run the water down the furrows left dry the first time, then change back the next time, etc. In Colorado, 13.76 inches of water was used to produce a 300-bushel crop upon a clay loam soil. It is important that land be allowed to dry thoroughly—for 30 days or more—before freezing weather, to permit the crop to ripen fully. The cost of production of irrigated potatoes, as reported from the Greeley district in Colorado, by J. F. McCrery is as follows:

"Plowing the land, $2.50; harrowing and leveling, $1; seed potatoes, $5; planting, $1.50; cultivating, $2.50; irrigating (distributing over field 3 times) $1.50; digging, $7.50; sacks, $7.50; marketing, $6; total, $35.

"Add to this $3.50 per acre for grading and inspection in the field, and we have a total of $38.50 for growing a good quality potato one year with another under irrigation."

FIG. 325. A modern two-horse digger will keep from three to ten or more men busy picking up and sorting

Under this system, yields of more than 900 bushels are reported from Washington, and of about 650 bushels from Idaho. (Adapted from W. H. Olin's, "Irrigation Farming.")

Harvesting and Marketing

Harvesting of the early crop takes place as soon as the tubers are large enough, and of the late crop as soon as the crop is mature, that is, as soon as the skin is firm and the potatoes will stand handling without rubbing. At this time, the vines are usually dead and the tubers will readily separate from the main stem. When they have to be pulled off, it increases the cost. If the tops have been frozen by an early cold snap, it may be necessary to dig before the tubers are quite mature. If the vines are killed by late blight, it is advisable to delay digging for at least 10 days, since there is then less liability from rot in storage.

Digging. Potatoes (especially earlies) are often dug by hand, a man being able to dig from one tenth to one half an acre a day, at a cost of 2 to 6 or even 8 cents per bushel. The commoner way is to plow them out; and on most small farms potato plows, or so-called "diggers," are kept for this work, some of which are small, modified shovel plows. With 2 horses to draw it and 6 to 10 hands to pick up, a digger will handle 1½ to 2 acres per day. In the southern states, the early potatoes are plowed out, and 10 cents per barrel is paid for picking them up. The ground is then harrowed and picked over again for those that have been missed.

The most satisfactory large-scale diggers are the horse-power machines which elevate the soil and the potatoes over shakers allowing the soil to drop through and depositing the potatoes in the rear. On some sandy soils, it is possible to remove all dirt and use the bagging attachment which puts the crop into bags instead of letting it fall on the ground. With these machines, 4 to 6 acres may be dug per day. From 8 to 16 hands are needed behind such a machine, but the cost should not exceed 2 cents per bushel.

Storage. It is easy for Northern farmers to store potatoes, although some prefer to sell to dealers who make a business of holding them. If potatoes can be moved direct from the field to storage cellars, it is the best way, and any one who is in the business would better plan to have a cellar built on a well-drained sandy loam foundation. It may be partly below ground, or there may be an approach, so that the potatoes can be shot down into the bins, to save handling. Large cellars have a driveway through the centre, so that the teams may load inside and save hand work. Bins are usually 10 feet wide and are filled 4 to 6 feet deep, divisions being put in as desired. Those who cannot afford a cellar may store potatoes outdoors in shallow trenches or pits made 3 or 4 inches deep, 3 feet wide, and as long as desired on some dry spot. Pile the potatoes not more than 3 feet high, cover with 3 inches of rye or wheat straw laid with the butts down, and on this place 2 or 3 inches of soil. The ridge is usually left uncovered for a few days, to let the potatoes sweat. If they are to be held here all winter, another covering of straw and another layer of soil will be needed, its thickness depending upon the amount of frost expected. The dangers to guard against are the entrance of frost and of rain, which may discolor the tubers, making them brown just as the sun makes them green. The disadvantage of pitting is that the pits cannot easily be opened in cold weather, when the potato market may be high.

Considerations in storage. Keep potatoes cool, preferably from 33 to 35 degrees F. There should be an air passage under each bin; in other words, do not place potatoes on the ground. Keep the cellar dark. Provide a ventilator in the roof, to take off the warm air, and some source of heat in very cold

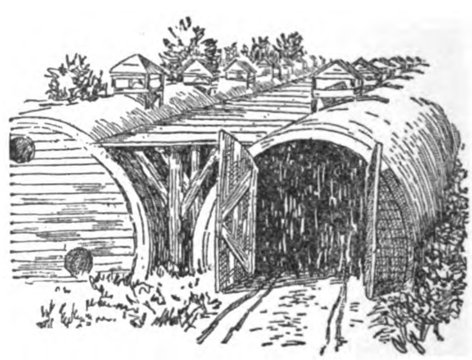


FIG. 326. In filling these concrete storage cellars, on a New York farm the wagons drive along the platform and dump the potatoes through the roof openings. The crop is taken out through the main passageways below. (Photo from Prof. E. L. Kirkpatrick).

weather. Combat wet rots and dry rots by thorough ventilation, and, where possible, whitewash and clean the storage cellar whenever empty. Apart from loss due to disease, insects, and the drying off of the soil, there is a normal shrinkage in weight due to use of energy by the plant to maintain its life. The total losses in storage, apart from loss due to disease, vary from 8 to 22 per cent.

Preparation for market. Grading is essential; all scabby, ill-shaped, diseased, and undersized tubers showing second growth should be removed. There are several grading machines, consisting, usually, of a revolving endless chain, belt, or link belting upon which the potatoes are thrown. These grade to definite sizes: the small ones fall through into boxes placed for them; the larger ones are carried along and thrown into other containers at the end. However, there is a growing demand for more careful grading than this; in some instances, select trade even calls for potatoes of absolutely uniform weight.

Potatoes are usually sacked or barreled, although large quantities are shipped from the main producing sections in bulk. Early crops are shipped in barrels holding 3 bushels, or 180 pounds, with canvas covers nailed, instead of heads, and sometimes ventilated through holes or slots in the staves; such barrels cost from 20 cents up. In the East, double-headed barrels, holding 165 pounds net and costing 30 to 35 cents, and strong burlap sacks, costing from 15 to 20 cents, are used for the later crops. On the Pacific Coast, burlap sacks, holding 100 pounds and costing about 5 cents each, are used. For local delivery, wooden 1-bushel crates are convenient and popular.

In filling barrels shake the potatoes down from time to time, fill more than comfortably full, put the head in with a press so that the potatoes cannot shake about, and nail just as in barreling apples. In sacking, take the same precaution before the bag is tied or sewn up. Potatoes bruised in transit are subject to dockage, partly because of the blemishes and partly because of increased danger from rot.

In shipping by carlot, especially during the winter, either refrigerator cars or cars with a specially constructed false bottom and side lining are used. This style permits the air to circulate all around the potatoes. A stove is put in the centre and an attendant accompanies the shipment to keep the fire burning. Frequently serious losses occur because of black heart—a black spot that develops in the centre of potatoes overheated from being too near the stove. To prevent this, set the stove so that the air is drawn from under the potatoes and sent upward and toward the ends of the car, and shield the potatoes near the stove from the heat; a temperature of 100 degrees F. may cause serious loss.

If no heat is used, it is well for the sake of both protection and appearance to cover the floor and sides with building paper before loading potatoes into the car. Put partitions across to prevent the potatoes from filling the doorway, and pile the tubers about 3 feet deep. A minimum car holds about 500 bushels; not more than 2 per cent shrinkage in transit should be expected.

FIG. 327. A storage house typical of the Aroostook section of Maine. (Farmers' Bulletin 847.)

Production costs and returns. Every means must be employed to maintain low cost of production. Rolling land may be used for potatoes, but it is not advisable to attempt to cultivate steep hillsides because of the expense incurred. When high yields are secured by the use of large quantities of fertilizer and special care, the cost of production per bushel is usually increased thereby. For instance, the cost of production per bushel in Maine will frequently run to 30 and 35 cents for an average yield of 225 to 275 bushels, whereas during the same season, an average production of 80 bushels might be secured in Minnesota at a cost of 22 cents per bushel. It is clear that a farmer in the latter place could sell at a profit for 25 cents a bushel, while a Maine farmer would avoid loss only if he received 8 or 10 cents more per bushel.

Distance to market, transportation facilities and rates are all important. If there is a good local market to which the freight rate is high, the profitable cost of production can still be much higher than in a region from which all of the crop is sent to a larger, more distant market. In some regions, therefore, potatoes may be grown on the highest-priced land with profit; in other sections, they become relatively unimportant even if the land, soil, and climate are suitable.

In a sense, the potato is best suited to home trade, for the crop is bulky and, usually, will not bear heavy transportation charges; hence we find the greatest production near the centres of population. The states along the Atlantic Coast have developed an extensive trade in potatoes partly because of the favorable climate and good soil, but largely because the crop can be shipped to market by water at much lower rates than are possible by rail.

UNITED STATES POTATO PRODUCTION

STATE	ACREAGE		PRODUCTION IN BUSHELS		AVERAGE YIELDS PER ACRE		AV. FARM PRICE PER BUSHEL	
	1916	1911–1916	1916	1911–1916	1916	1907–1916	1916	1907–1916
New York	320,000	356,000	22,400,000	31,695,000	95	94	$1.58	$.74
Michigan	320,000	344,000	15,360,000	30,296,000	48	90	1.60	.58
Wisconsin	290,000	309,000	13,630,000	29,467,000	47	97	1.47	.55
Minnesota	280,000	260,000	16,800,000	27,830,000	60	99	1.30	.54
Pennsylvania	272,000	270,000	19,040,000	22,444,000	70	83	1.48	.78
Ohio	140,000	163,000	6,300,000	12,753,000	45	79	1.82	.78
Maine	125,000	126,000	25,500,000	25,637,000	204	206	1.42	.64
Virginia	125,000	112,000	16,250,000	10,573,000	130	90	1.37	.78
Illinois	125,000	112,000	7,250,000	9,166,000	58	75	1.79	.81
Iowa	115,000	151,000	4,830,000	12,342,000	42	79	1.75	.72
Nebraska	105,000	114,000	7,665,000	7,298,000	73	73	1.50	.74
U. S. total	3,734,000	3,700,000	359,721,000	361,609,000	80.4	95.4	$1.46	$.69

As a rule, the central-western market prices are higher than those along the Atlantic Coast. Under normal conditions, if prices are high, European potatoes may compete with the eastern crop because of the low cost of water transportation; high freight rates prohibit their movement into the Middle West. (S. F.)

Note in the table, on page 283, which shows the world's production of potatoes, that in the year given Russia led in point of acreage, Germany in point of yield, and the United Kingdom in average yield per acre. Compare with the map on p. 275 and the one below.

ROOT CROPS FOR STOCK FEEDING. Under this heading may be included mangels, sugar beets, turnips, hybrid turnips, rutabagas, kohlrabi, carrots, and parsnips, all of which are raised as stock feed in the same general way. Parsnips, carrots, turnips, and kohlrabi, as garden vegetables, are discussed in Chapter 28, and sugar beets, as a source of sugar, on page 284. These are all biennial plants. The first year they devote themselves to storing up food, either in a thickened stem or root or both; the second year, to the production of seed. As usually grown they

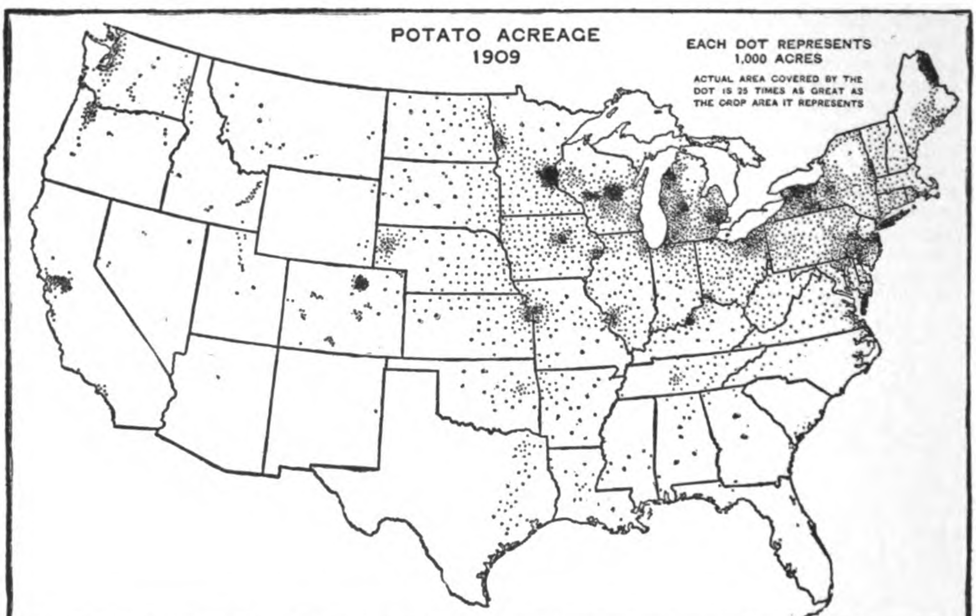


FIG. 328. This map and the table above it show clearly that the potato is a crop for the cooler parts of the humid section. Except in Maine, the yield per acre is far less than it should or need be. (1915 Yearbook, U. S. Dept. of Agr.)

WORLD'S POTATO PRODUCTION

COUNTRY	YEAR	ACRES IN POTATOES	PRODUCTION IN BUSHELS	AVERAGE BUSHELS PER ACRE	PER CENT OF CROPPED LAND IN POTATOES
Russia	1913	11,520,000	1,274,455,000	115	4.5
German Empire	1915	8,827,000	1,983,161,000	190	13.5
Austria-Hungary	1913	4,926,000	627,728,000	137	8.5
United States	1915	3,734,000	359,721,000	95	1.5
France	1915	3,225,000	332,788,000	115	7.0
United Kingdom	1915	1,201,000	281,502,000	210	7.5
Spain	1914	688,000	76,657,000	130	2.0
Italy	1915	725,000	56,768,000	85	2.3

become annual crops, for they are taken up and used as food at the end of the first season. They all occupy the land throughout the growing season, and, generally speaking, the earlier they are planted the better. They represent several families; sugar beets, mangels, and table beets being derived from the same original wild plant; turnips and hybrid turnips being closely related; rutabagas and kohlrabi belonging to the cabbage family; and carrots and parsnips belonging to still another family.

As grains have become high-priced, root crops have come to occupy an increasingly important place in northern agriculture. Here it is easy to raise comparatively large amounts of roughage, but relatively small amounts of concentrates are produced; root crops can here be used to take the place of concentrates in the ration to a certain extent. Because root crops have a relatively high water content, the idea is general that they cannot entirely supplant cereals or concentrates in the ration. Yet the writer knows of one New York farmer who has for 6 years maintained a production of 8,000 pounds of milk per cow on home-grown feeds—alfalfa, corn silage, and mangels.

Since dry matter is the true basis on which to value these crops for feeding purposes, the following list of the relative yields of dry matter per acre in pounds, secured during 3 years at the New York Experiment Station at Cornell University, is of interest:

	MINIMUM	AVERAGE	MAXIMUM
Mangels	2,168	5,155	8,453
Half-sugar mangels	5,480	5,880	6,440
Sugar beets	6,014	7,090	8,090
Rutabagas	3,537	4,331	5,079
Hybrid Turnips	2,584	3,694	5,111
Common Turnips	1,710	2,680	3,500
Kohlrabi	3,570	4,070	4,540
Cabbages	4,076	4,662	5,588
Carrots	1,878	3,134	4,379
Parsnips	2,080	3,130	3,680

However, one pound of the dry matter in one crop is not necessarily equal in value to that in another crop; for there is such wide variation in the composition of this dry matter itself that the roots grown on one field may be actually worth twice as much as those grown on another, even when all are the same variety.

These crops are all grown as cleaning crops, and are usually taken after sod and immediately preceding a grain crop, which frequently must be oats, because there is not sufficient time in the fall to prepare the land and sow it after the root crop comes off. Turnips and kohlrabi on sandy loam soils might well be pastured off. Cowhorn turnips are sometimes grown as a cover crop to be plowed under.

Where grown. The climatic conditions favorable for these plants are those of the humid regions, with the exception of the sugar beet, which can be profitably grown with irrigation farther south. Cool, equable climates are best. The soils used vary widely, good crops being grown on all types, from sandy to clay loam. A sandy loam is usually preferred for carrots, because the plants grow with the major portion of their root in the ground. Mangels and sugar beets can withstand drought better than most other root crops. Turnips require free-working loams fairly rich in organic matter and good tilth. The climate must be suitably cool, and there should be sufficient rainfall throughout the season to keep the plants growing steadily. Kohlrabi will grow wherever turnips will. Carrots and parsnips, both germinating slowly, must have a soil free from weeds.

How grown. Soil preparation consists of fall plowing and very careful fitting of the land in the spring. The land may be manured and fertilizers applied. Sometimes these are applied in the row below the seed. From 500 to 1,000 pounds per acre of high-grade fertilizer fairly high in nitrogen are used The use of phosphatic fertilizer is advised especially for turnips. Liming is generally of advantage, since it tends to control clubroot, which affects turnips, rutabagas, and all members of the cabbage family. From 1,000 to 2,000 pounds per acre are usually applied. Fertilizers should all be well mixed with the soil;

it is better to take an extra week, if need be, to fit the land properly rather than put the seed in a poorly-prepared seedbed.

The soil should be so drained that water will not stand on it and that good mechanical condition can be maintained throughout the growing season. Root crops must be maintained in vigorous growth during the whole season, so that they may overcome any troubles which attack them, prevention or cure by spraying being absolutely impossible.

Seeding. Seeding is usually done as early as possible, usually in May in a district like New York, although the common turnips may be sown later. Some of the strap-leaf turnips may be sown as late as August, but the yield will not be high. The amounts of seed usually sown per acre are: mangels and sugar beets, 8 to 12 pounds; carrots, 6 to 8 pounds; rutabagas and kohlrabi, 4 to 5 pounds; turnips, 2½ to 3 pounds; parsnips, 6 to 8 pounds.

A specially constructed drill is ordinarily used; it may be a hand drill, if a small amount is to be used, or a horse-drawn tool which plants 4 rows at a time. It is preferable that the seeds be dropped in hills at the required distance apart rather than in continuous rows, since it saves thinning. Two or 3 seeds in a hill would in most cases, be necessary.

The aim is to have the seedbed very well fitted and quite fine, so that the seed may be sown from half an inch deep for the small seeds to three-quarters of an inch deep in the case of large ones. It should always be covered. Except for carrots and parsnips, in due course the seedlings appear; careful cultition must be given as soon as they are up, and the plants must be thinned as soon as they are large enough to handle. The thickness of seeding will naturally depend upon the probable germination. It is important that this be known, otherwise there may be too few or too many plants.

It is usually advisable to make the rows fairly wide apart (30 inches is common) and the plants closer in the row, so there are fewer rows per acre to cultivate. Rutabagas, kohlrabi, hybrid turnips, and long mangels are usually left about 8 inches apart in the row; tankard and globe-shaped mangels, 10 inches; and carrots and parsnips about 4 inches.

Cultivation begins as soon as the plants are up, and is maintained until they meet in the rows. They must be kept clean and properly thinned as soon as the turnips are in rough leaf and the mangels have attained 4 leaves. If allowed to stand too thick in the row, plants become spindly and drawn, and they lose value. Stunted plants are best helped by an application of 100 pounds of nitrate of soda per acre. In dry weather, constant cultivation is of value.

Harvesting. Harvesting generally takes place as soon as serious frost threatens. Crops usually grow vigorously up to that time, but mangels and sugar beets particularly should not be frozen, if to be kept. Parsnips may be left in the ground all winter, and carrots, owing to the fact that they grow to a large extent below the surface, will stand more frost. Sugar beets, which grow to a considerable extent in the soil, are frequently harvested by means of a sugar-beet puller, which virtually lifts them out of the ground. Mangels grow sufficiently out of the ground so that they can be pulled by hand. With a stout knife in one hand a man pulls a plant with the other hand and slices off any fibrous roots which may carry soil attached; he also cuts off the neck or, in the case of mangels, twists the leaves off, throwing 4 rows into 1, that is, 2 from each side. In the case of turnips and rutabagas, the tops are cut off as well as any roots which may carry soil. As soon as possible after pulling, the crop is hauled to storage. For temporary storage, pits will do, but, if the crop is to be used throughout the winter, it must be kept in a roothouse or other suitable place.

In feeding, the common turnips (and cabbages) should be fed first, that is, in the earlier part of the season, then the rutabagas, the mangels, and, finally, the carrots and parsnips.

Varieties. In the case of mangels, 5 shapes are recognized in the United States: long, half-long, ovoid, tankard, and globe; a sixth, the cowhorn, is grown in Europe. The skin may be white, pink, red, orange, yellow, golden purple, or black. The long varieties are usually the most productive in total yield and in dry matter. The globe varieties, although they are easier to harvest because they do not grow so deeply in the ground, usually contain the lowest percentage of dry matter. They are adapted to shallower soils than the others.

In turnips, we have flat, round, and tankard shapes, which vary in skin color from white to purple and in flesh color from white to yellow. There is the same variation in rutabagas, and hitherto more emphasis has been placed on these external characters than on the feed value of the plants. Thus some varieties are known as purple-top *Tankard* or *Green-top Globe*, and usually the seedsman's name is placed in front of these.

In the case of kohlrabi, we have *White* and *Purple Vienna* as the two leading varieties. In the case of carrots, some of the leading varieties are the *Long Orange* or *Long Red*, *Danver's Half-long*, *Early Horn*, *Altrincham*, and, of the larger, cattle carrots, *Wiltshire*, *Giant White*, *White Belgian*, and *Yellow Belgian*. In parsnips there are but a few varieties, such as *Student* and *Hollow Crown*. (S. F.)

SUGAR BEETS. (See also root crops for stock feeding, p. 282). These are grown for the manufacture of sugar from the roots and, to a slight extent, as a stock feed. The

method of extracting sugar from beets was discovered in 1747; but practical use was not made of it until the next century, when factories were established throughout France and Germany. The introduction of the crop into the United States was slow, the first successful factory being established in California in 1869. The table at the bottom of this page shows the growth of the industry from 1899 to 1909 in this country, where it is still increasing. The leading sugar-beet-producing states in 1909 were Colorado with 108,082 acres and an average yield of 11.4 tons of beets per acre; California, 78,957; Michigan, 78,779, averaging 8.98 tons; Utah, 27,472, averaging 15.07 tons; Idaho, 15,601; and Wisconsin, 12,379. Before the European War, half the world's sugar was made from beets, Germany, Austria-Hungary, France, and Russia being important production centres.

Sugar beets differ in their sugar content, so that it is important to have seed from plants that are rich in sugar value. Further, the sugar content seems to be grealy influenced by the character of soil and climate, the beets highest in sugar being those grown in rather high altitudes and where there is a relative scarcity of moisture immediately preceding the harvest period. Too much rain during the late summer may cause the beets to make further growth and thus lose much of their sweetness. The aim is to produce moderate-sized roots, weighing fully 1 pound each, with a minimum sugar content of 14 per cent and at least 80 per cent of the total solids of the juice, cane sugar. With a price of $5 per ton for the beets on board the cars, this would insure a return of $90 to $100 per acre, if the yield were 19 to 20 tons per acre; as a matter of fact, the probable yield is nearer 10 tons, except under irrigation. A large part of the crop in the United States is, therefore, grown under irrigation.

Seed improvement. The present effort is toward a reduction in the cost of producing sugar. The fact that a single seed-ball may send up two plants necessitates great care in thinning; the aim is to meet this condition by developing a strain in which there is but one seed in a seed-ball. Great care is taken in the selection of "mother" plants to be used for seed production. The method consists of taking a core, or sample, out of a promising root and testing it for sugar and the purity of its juice. If the plant is desirable in shape, with colorless skin and juice, and rich in juice and sugar content, it is saved and planted the following spring in specially prepared ground. These roots are usually set out 3 feet apart each way and encouraged to make all the growth and set all the seed they can. None but plants of the highest value is permitted to grow nearby, to avoid the possibility of contamination from outside pollen. By such judicious selection of desirable mother plants, great improvement has been brought about in the last hundred years. Formerly, but 3 per cent. of the sugar beet was saved as sugar; to-day, 4 times as much is recovered. Part of this gain is due to better methods of manufacture, and part to an increase in the sugar content of the beets. In 1860, this averaged about 11 per cent; to-day (1917) it is about 17 per cent, with some individual roots running over 25 per cent. The pulp remaining after the sugar is extracted is valuable as a stock feed, and constitutes an added source of income.

Growing the crop. Sugar beets are grown in soils of various kinds, from the heavy black soils of California and Montana to the sandy loams and silts of river bottoms. Too much sand may mean a low sugar content; gravelly soils, also, are poorly suited to the crop; heavy clay soils or soils having a layer of hardpan near the surface cause prongy, poorly shaped roots; and beets grown in muck soils are apt to be lacking in sugar content.

Soil preparation for sugar beets should include deep plowing, the depth being best reached over a series of years rather than all at once. The seedbed should be firmed by proper working, but on top there should be a layer of well-pulverized but looser soil.

Seed are drilled in rows and are later thinned, so as to stand the desired distance apart. The distance between the rows varies greatly in different localities and under different conditions, ranging from 14 to 36 inches, so that the quality of seed required is from 5 to 25 pounds per acre, with 15 pounds a fair average. When the young plant has 4 leaves, it is ready for blocking and thinning. Blocking consists in chopping out the plants, leaving a "block," or small bunch every 8 to 12 inches. Later, this bunch is thinned down to one good, vigorous plant. Much depends upon the manner in which the thinning is done. If the soil about the young plants is loosened, it should be pressed back in place.

Cultivation is begun as soon as the beets are of a size that the rows can be followed, and is continued until the crop is "laid by." Surface cultivation is usually favored, although

GROWTH OF SUGAR BEET INDUSTRY IN THE UNITED STATES

	ACREAGE	PRODUCTION	AV. YIELD PER ACRE	AV. PRICE PER TON	TOTAL VALUE	VALUE PER ACRE
1899	110,170	793,353 tons	7.2 tons	$4.19	$ 3,323,240	$30.16
1909	364,093	3,933,000	10.8	5.06	19,880,724	54.60

many growers advocate deeper cultivation for some soils.

Harvesting requires the use of several special tools, and consists of 4 operations—lifting, pulling, topping, and hauling. Getting the heavy-rooted beets out of the ground requires considerable power, and is usually accomplished by the use of special plows. Topping consists of removing, with a blow of a heavy knife, the crown of the beet at the point of the lowest leaf scar. The reason for removing the crown is that it contains so much mineral matter that it is not best to use it in sugar making. In hauling beets from the field to railroad or factory, a wagon provided with a large hinged rack is used. Forks used in handling beets have heavy tines with protected points.

Cost of growing. The cost of growing an acre of sugar beets in Colorado has been figured as follows, for normal times: Manuring, $5; plowing, $2; leveling, $.50; harrowing, $.75; floating, $.20; ditching, $1; seed, $2; planting, $.40; three to five cultivations, about $2; contract labor, $20; irrigation, harvesting and marketing, $7; interest, $17.50; taxes, $2; total $60.35. (S. F. and W. L. N.)

SUNFLOWER. The sunflower, while found growing wild in the Great Plains region of the United States, has never been much grown as a cultivated crop in this country. It is extensively grown in Russia, where the seed constitutes an important article of food. Russia is also the source of the best seed brought into the United States. Plants of the Mammoth Russian and Black Giant varieties often attain a height of 12 to 18 feet, while the seedheads may measure 20 to 22 inches in diameter. Sunflowers have been grown to a limited extent as a field crop in Kansas and Missouri.

The great need is a stable and dependable market for the seed, the price of which may vary from 2 to 10 cents per pound. As a poultry food, the value of sunflower seed has long been recognized. The seed is especially rich in protein as well as fats. When crushed, one of the by-products is a valuable oil.

As to culture, there is considerable similarity between the corn and sunflower crops.

Planting is usually in drills, the rows being from 3 to 3½ feet apart, and the seed from 14 to 20 inches apart in the rows. One seed is dropped to the hill. This can be done by preparing a special plate for the ordinary corn planter with drill attachment. Seed should not be planted too deep. A good depth in well-prepared soil is from 1½ to 2 inches. Four or 5 cultivations are usually given; the first should take place when the plants are 3 to 6 inches high. When about 20 inches high the plants should be thinned. The weak ones are chopped out, as are those that show a tendency to branch. When grown for seed, the sunflower at maturity should bear only one terminal flower. The many-flowered varieties should be planted for oil only.

Harvesting is begun at the time most convenient after the crop is matured, preferably after 2 or 3 heavy frosts, provided the weather is not too damp. Harvesting is usually done by men in wagons, who, driving along, reach out and pull over the seed-filled heads and cut them off with corn knives.

It is important that the seed be thoroughly dry before any effort is made to thresh. Where the threshing is done by beating, it is necessary to fan the chaff out with an ordinary grain fan. (W. L. N.)

FIG. 329. Planting sugar cane in Louisiana by dropping pieces of stalk in freshly made furrows

SUGAR CANE. Sugar cane is one of the largest of the family of grasses (*Graminaceae*) to which it belongs. It usually reaches a height of 9 to 11 feet. The seeds are very small and many are infertile.

The time required for a plant starting from a cutting to produce seed is 14 to 18 months, so that seed is seldom matured in continental United States. The method of propagation is from cuttings.

Where grown. In the United States, the sections best adapted to cane growing are in the extreme southern portions of South Carolina, the southern third of Georgia, Alabama, and Mississippi, the southern half of Louisiana, the low coastal plains of Texas, and all of Florida. In 1909, the sugar-cane crop of the United States was grown on 476,849 acres. The yield was 6,240,260 tons, valued at $26,415,952. Louisiana is the leading sugar-cane producing state, having harvested 4,941,996 tons in 1909.

Soil. Cane makes a heavy demand upon the soil. The best soils are medium-heavy loam or clay with an abundance of humus. Very sandy soils are not well suited to continuous cane growing. They may yield satisfactorily at first, but do not retain commercial fertilizers well, and are soon exhausted. Sandy soils near river banks, and rich in deposits of silt, are rather an exception to this rule. Heavy clay is not good unless it contains vegetable mold or considerable humus in some form. Muck soils having a high mineral content will, if well drained, produce big yields. Where the ground is low and flat and the ground-water level is within 3 feet of the surface, artificial drainage is necessary.

Commercial fertilizers. These are largely used. Soil requirements differ greatly, but, generally, nitrogen in some form is essential. Applications may vary from 20 to 50 pounds per acre. Soluble phosphoric acid is used at the rate of 40 to 80 pounds per acre, and on thin soils up to 120 pounds. Potash has resulted in little or no benefit, except in states east of Louisiana.

Natural manures. Natural manures, such as green crops plowed under and barnyard manure, result in increased yields. Stable manure is best applied to the preceding crop. Cottonseed meal is a good fertilizer for sugar cane. Crop rotations are important. A good plan is to precede cane with corn and cowpeas.

Planting. In the United States, sugar cane is planted both in fall and in spring. Much of the Louisiana and Florida crop is planted in the fall. Owing to the fact that labor is more plentiful early in the season, most planting is completed by the end of October, but can safely be continued until danger of frost prevents. Where planting is not completed in the fall it is finished early in the spring, usually in February or March. In Georgia, spring planting is the rule. When preparation of the ground has been completed, the cane is planted in furrows. Either the whole stalk or any part of it is used. In the rich soils of Louisiana the rows are usually 5½ to 6 feet apart; in southern Georgia, 4½ feet.

Wide spacing is the rule where the cane makes rapid growth and where the season is long. The rate of planting varies. In Georgia and Florida the aim is to get at least one continuous round of cane. In Louisiana, with the rows farther apart, "2 lines and a lap" is common practice. This requires 3 to 4 tons of cane to plant an acre, if whole stalks without rootstocks are used. In spring planting, cane is covered to a depth of 1 to 2 inches. Fall planting is 4 to 6 inches deep, but a part of the soil is removed in the spring. Where the roots of the cane are not dug up, the rootstocks remain alive and the next year send forth sprouts called ratoons. This crop, which is known as the "stubble crop" or "ratoon crop," is seldom as good as a "plant-cane" crop. A second ratoon crop is apt to be smaller than the first, so that ordinarily it is not profitable to take more than 2 crops from a planting.

Cultivating and harvesting. In the spring, before the plants are up, or when they are very small, it is a good plan to use a spike-tooth harrow or spring-tooth weeder. Hand hoeing is frequently necessary. Of the cultivations that follow and continue until the crop is laid by, about July 15 or August 1, the first are deep, and the latter shallow. Harvesting consists of stripping the leaves off the stalk, topping the cane, cutting off at the bottom, dropping it in bundles, loading, and hauling to the mill. In Louisiana, an ordinary cane knife is generally used in cutting off the cane, while in the eastern Gulf states a heavy hoe serves this purpose. Harvesting, except in Florida, usually begins by the latter part of October. A heavy freeze followed by warm weather may cause the cane to sour and become worthless for sugar or sirup, but a light frost may not seriously damage the crop.

FIG. 330. Sugar cane cut and ready to be harvested. It is laid evenly in rows which are then loaded into wagons

Yield. On Mississippi delta land 25 to 35 tons of sugar cane is a fair crop from the first planting. The first ratoon crop is about one third less, and the second only about one half the original. Farther east, a fair crop would be 18 to 25 tons. The yield of sugar under favorable conditions is 140 to 180 pounds per ton of cane. Yield of sirup is 18 to 24 gallons per ton of cane, or about 400 to 525 gallons per acre of plant cane on good Georgia or Florida farms.

Varieties. The varieties most extensively grown in the United States are *Louisiana Purple*, known also as *Home Purple*, and in Georgia and Florida as *Red Cane*, and the *Louisiana Striped*, known as *Ribbon* or *Red Ribbon*. (W. L. N.)

SWEET POTATO. The sweet potato, which is largely grown throughout the tropics and the warmer temperate zone for its edible roots, is related to the morning-glory. The edible portion of the sweet potato, unlike the white potato, is not a tuber, but is a true root. The skin ranges from light tan to red or purplish color, and the flesh from pale lemon to deep reddish orange. The sweet-potato crop is an important one on the southern states, as food both for man and for beast. It does not do well farther north, except in a few favored locations, as frost is fatal to the vines of most varieties. Census figures show that in 1909 the sweet potato and yam (yams are the more watery fleshed sorts) crop of the United States, grown on 641,255 acres, amounted to 59,232,000 bushels. North Carolina led with 8,493,283 bushels. States ranking next in total production were, Georgia, Alabama, Virginia, Mississippi, South Carolina, Louisiana, New Jersey, Texas, Tennessee, Florida, and Arkansas.

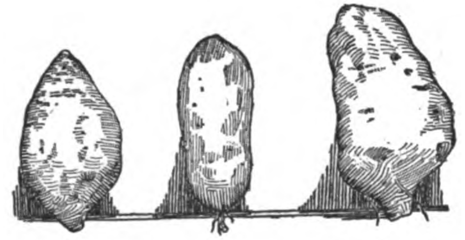


FIG. 331. Types of sweet potato. From left to right: Golden Beauty, Pumpkin Yam, and Enormous. As to flesh character, tne dry, yellow sorts are preferred in the North, and the lighter colored, moister sorts in the South. (Ga. Bulletin 107).

Growing the crop. Sweet potatoes grow best in a warm, fertile, and somewhat sandy soil. Poorly drained soils, especially during wet seasons, are apt to result in tubers that are long and stringy instead of plump, as desired. Commercial fertilizers and stable manures give good results. After the ground has been plowed and worked down much as for ordinary field crops, it is thrown into broad ridges about 4 feet apart. The "slips," which come from old potatoes placed in hotbeds several weeks in advance of the field-planting season, are pulled when they are 6 or 8 inches high (including root and top) and are set 15 to 18 inches apart in the rows. Large planters have their own propagating beds, but small growers frequently buy the plants as needed. Cultivation to prevent the growth of weeds should be frequent and thorough as soon as the young plants have taken root, as it is impossible to use horse-drawn cultivators after the vines have attained any length.

Digging and storing. In harvesting large crops of sweet potatoes, special diggers are often used. A common type of digger consists of single or double plowshares equipped with rolling colters to cut the vines. When plowed out, the potatoes are pulled from the vines, and are generally allowed to dry for a short time before being removed from the field. In marketing, it pays first to cull out the small potatoes and "strings." If the crop is to be stored, instead of sold as soon as harvested, storage is an important item. Most storage houses are built above ground, as dryness is a necessary factor. With this object in view, a temperature of about 90 degrees should be maintained for several days after the house has been filled. Later this is lowered to 50 or 60 degrees. (W. L. N.)

TARO. The taro plant, extensively grown in Hawaii, is a perennial herb the thickened underground part of which is used for food. There are many varieties, and 2 general types: (1) water taro, which grows partly under water, and (2) dry-land taro, which really grows on land amply supplied with moisture but which is not submerged. Taro grows in the muck soils of the valleys, and on uplands where moisture is plentiful. It is propagated by planting crowns of mature plants, together with a few inches of the leafstalks. The crop is ready to harvest in 13 to 15 months. It is used as a vegetable and in the making of poi, a dish much relished by natives of Hawaii. (W. L. N.)

TEA. Tea is not grown commercially in the United States, although experiments conducted at Greenville, South Carolina, prove the possibilities of growing the crop in this country. However, it is doubtful whether we can compete with China, Japan, Ceylon, and other countries where tea has long been grown commercially. Tea plants vary in height from 30 to 40 feet in the deep soils in some of the valleys of the Orient, to the stunted bushes only 2 or 3 feet high in the more northern districts. Black teas come mainly from warm climates, and green teas from cooler ones. However, either kind may come from all tea leaf, as the difference is due to the fact that green tea is non-oxidized, while black tea is oxidized.

Tea does best in a deep, fertile soil which permits of comparatively free passage of both air and water. Ample rainfall, especially in a hot climate, is essential throughout the cropping season.

The pruning of the tea plant is a subject on which growers are not agreed. Pruning keeps the bush of a size that the leaves can be reached by the pluckers, and also tends to stimulate new growth. Under favorable conditions, the work of pruning and plucking may be continued for many years without robbing the plant of its vitality. After being gathered, tea leaves are rolled so as to break the oily cells containing the substances which make them valuable for brewing the beverage. The leaves are then dried so as to prevent fermentation and decay. (W. L. N.)

TEASEL. The teasel is a biennial plant, grown in Europe and, in a small way, in New York and possibly in 1 or 2 other states. There are a number of species, but only one variety that has a commercial value. This is Fuller's teasel, the heads of which are used

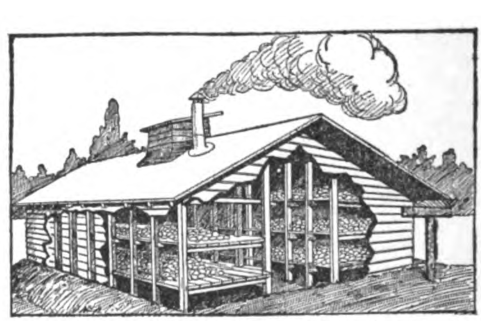


FIG. 332. Beeson sweet potato kiln partly cut away to show arrangement of interior. (International Harvester Co.).

in raising nap on cloth. The main plant produces a big, strong teasel, the male teasel, commonly referred to as the "king." At the ends of the branches there are usually many "queens" or "mediums." The smallest teasels, which grow on the little branches, are termed "buttons." If the "king" teasel is removed, seed from the plant will not germinate.

Teasel seed should be sown, in the spring, on well-prepared ground at the rate of 1 to 2 pecks per acre. The seed is drilled in rows which should be 3 to 3½ feet apart. After the young plants have been given 1 or 2 cultivations, they are thinned, so as to stand 8 or 10 inches apart in the rows. In order to get some return from the land the first year, corn may be planted with the teasels. Harvesting, which usually takes place in August of the second year from planting, consists in cutting off the ripened heads on which stiff, recurved hooks have formed. Yields vary from 100,000 to 300,000 heads per acre. Cloth manufacturers are the principal buyers. (W. L. N.)

TOBACCO. The tobacco plant is native to America. The leaves were probably used for smoking purposes long before the coming of the white man. Tobacco is used also for chewing and snuff and for medical purposes. As early as 1612, the systematic cultivation of tobacco was begun in Virginia, and by 1731 the export of tobacco from Virginia and Maryland had reached 60,000 hogsheads of 600 pounds each. In New England, also, tobacco culture began at an early date.

Soil and climate have a great deal to do with the character of the tobacco plant. Flavor, aroma, and texture may all differ greatly, depending upon where the tobacco is grown. A change of seed from one section to another may cause marked variability, and may even lead to the introduction of new varieties. It was in this way that *White Burley*, the most extensively grown variety in the United States, was originated. Varieties, of which there are a number, might be divided into the following classes: (1) Cigar wrapper and binder, (2) cigar filler, (3) chewing or plug, (4) smoking, (5) export tobaccos.

FIG. 333. Part of a teasel plant showing the stiff, prickly heads for which the crop is grown.

The seedbed. In growing tobacco, it is important to have strong, healthy plants ready to set in the field at the proper time. The location of the seedbed should be such as to provide good drainage and abundant sunshine and should also be convenient to water supply. The soil should be rich in easily available plant food, as the seeds of tobacco are very small and have stored up but little nourishment for the young plant. Furthermore, a vigorous growth in the field can come only from strong, healthy seedlings. In preparing the seedbed, it is customary to sterilize the soil either by steaming, roasting, or surface firing. In the latter plan, which is quite common, a fire of brush, logs, or other material is made where the bed is to be located. The object is to destroy weed seeds and to prevent the development of bed-rot and root-rot diseases in the seedbeds. The formalin treatment has also been recommended for the control of bed-rot. The surface of the seedbed should be thoroughly fined and, after the seed has been sown, should be compacted on top. In sowing, a good plan is to mix the seeds with ashes, cornmeal, or some other substance, so as to secure a more even distribution. An even tablespoonful of seed will sow about 1 square rod. One ounce of seed is said to contain about 300,000 seeds. The seedbed is covered with cloth, and is watered from time to time, as needed. The bed should be thoroughly watered just before the plants are removed for transplanting.

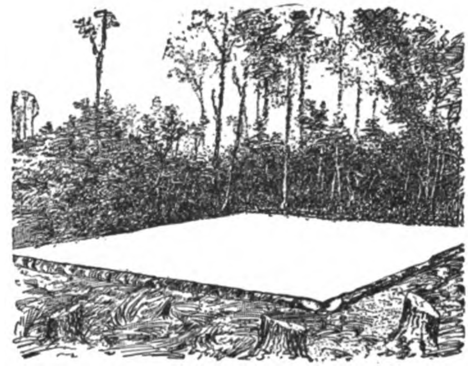


FIG. 334. A cloth-covered tobacco seedbed on newly-cleared land

Transplanting and cultivating. When the plants have made sufficient growth, and when soil and weather conditions are right, they are set in the field. Well in advance of this the tobacco land has been plowed and given occasional harrowings, so that weed seed will be destroyed and moisture retained. The plants are set in rows, a planter drawn by 2 horses being in general use. Such a machine requires a driver and 2 men who alternate in setting the plants. A gearing arrangement liberates a small quantity of water, carried in a tank which is a part of the planter, at given

FIG. 335. Some types of tobacco resist disease more than others. These 6 rows were planted at the same time and received the same care. *d* and *f* show normal growth, the rest show the varying effects of root-rot disease. (Wis. Bulletin 277).

distances. This also indicates where the plants are to go. The distance apart that the plants are set depends upon the soil and upon the variety and character of the tobacco. Plants are set from 18 to 30 inches apart, with rows 36 to 48 inches apart.

The cultivation of the crop should be such as to keep down all weeds and to provide a good mulch. The hand hoe is much used. In addition to ordinary tillage implements some special tobacco cultivators are on the market. Cultivation continues until the leaves spread out to an extent that to continue the work would damage the plants.

Topping and suckering. In growing tobacco, the seed head is removed, so that the nourishment which is in the plant may be kept for the leaves instead of being used in the formation of seed. Topping consists in cutting or pinching out the buds. Upon the variety of the tobacco, as well as upon soil and climatic conditions, depends the amount of top to be removed. The number of leaves left to develop upon the plant may vary from 12 to 20. Plants selected for seed are, of course, not topped. Following topping, suckers appear, and if the weather is moist and warm, they develop very rapidly. They are removed in order to prevent the waste of plant food and moisture needed for the main leaves. Some strains produce many more suckers than others.

Harvesting and curing. As harvesting and curing differ considerably in the various classes of tobacco, it is possible to describe only in a general way these processes.

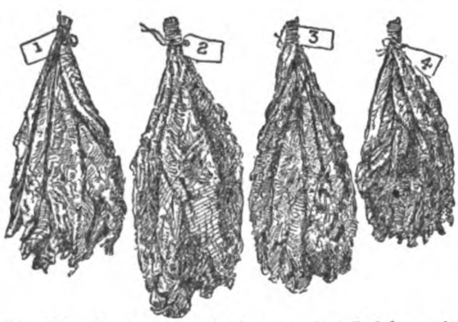


FIG. 336. Four grades of tobacco as bundled for curing and sale

Most tobacco, as grown in the United States, is harvested on the stalk at about the time the middle leaves of the plants are ripe. "Priming," or removing the leaves separately as they ripen, and leaving the stalks in the field, is but little practised. When the whole plant is harvested, it is cut off near the ground. As soon as it has wilted sufficiently to be handled without breaking, it is strung on laths or tobacco sticks, preparatory to being taken to the sheds. Wagons on which the tobacco is hauled from the fields are provided with frames on which the loaded laths are hung. Worms and suckers, if any, should be removed from the tobacco before it is hung in the shed, where the ends of the laths rest on horizontal supports. Most of the crop is housed by the last of September.

Tobacco sheds are specially constructed buildings, proper ventilation being highly important. While tobacco, in curing, gives off much moisture, the process is more than one of drying. During the curing period, which continues for several weeks, the handling of the many doors or ventilators with which tobacco barns or sheds are provided depends upon the weather and also upon the kind of tobacco. It is not always an easy matter to control temperature and moisture conditions inside the barn. Failure to do so, though, may result in the loss of the crop, or at least in lowering the quality. During rainy or foggy weather, the humidity in the sheds may become excessive. At such times every effort must be made to promote ventilation, so as to prevent poleburn, or polesweat, especially during the early stages of curing. During ordinary hot and dry weather, the ventilators are opened or closed as needed. Regulating conditions is not then so difficult a matter. Heating systems, to hasten curing or to increase the circulation of air, are common. Some tobacco is field-cured in the sun.

FIG. 337. Sun-curing tobacco as practised in the South. (Va. Bulletin 197).

After the tobacco is cured, it is dry and brittle and cannot be handled until it takes on enough dampness to cause it to become elastic, or to "case." In the meantime it is sorted according to grade and color.

Extent of production. In 1909, according to the Thirteenth Census, tobacco was grown

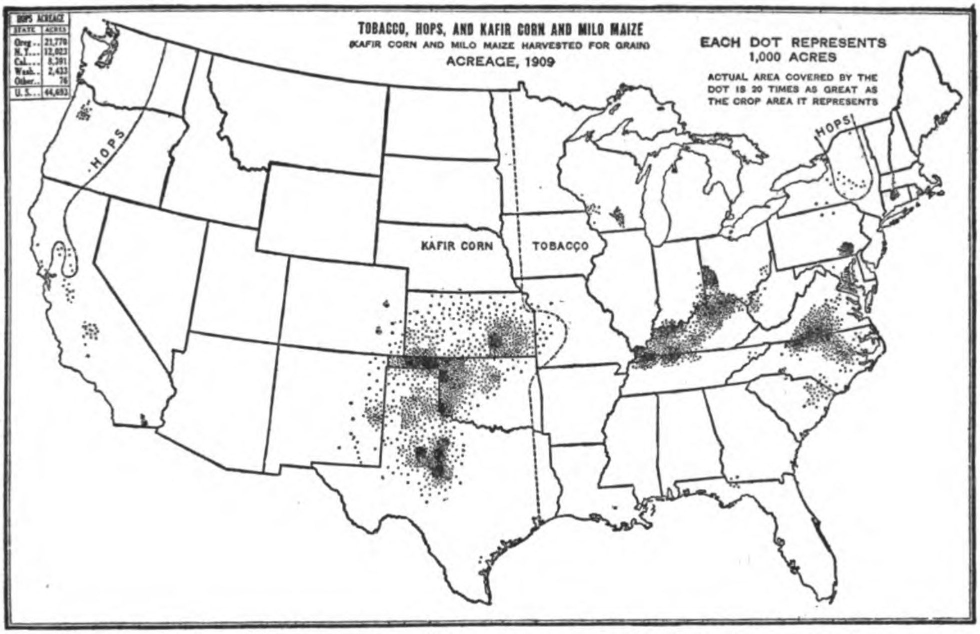


FIG. 338. For statistics and cultural directions of these crops see page 223 for kafir; page 273 for hops; and this and the preceding pages for tobacco. (1915 Yearbook, U. S. Dept. of Agr.)

on 326,919 farms in the United States. The crop from 1,294,911 acres amounted to 1,055,764,806 pounds. States producing more than 25,000,000 pounds each were: Connecticut, 28,110,456 pounds; Pennsylvania, 46,164,800; Ohio, 88,603,308; Wisconsin, 46,909,182; Virginia, 132,979,390; North Carolina, 138,813,163; South Carolina, 25,583,049; Kentucky, 398,482,301, and Tennessee, 68,756,599. (W. L. N.)

F. FIBER CROPS

Every good farmer believes and usually knows that he can raise a certain crop or kind of stock better than a lot of others. But his successful methods may not be applicable without some changes throughout the country. The facts and methods outlined below have been collected from the most practical, authoritative and up-to-date publications and are vouched for by practical growers as thoroughly sound for average conditions.—EDITOR.

Cotton

Cotton has been known since the earliest civilization, and is to-day the world's greatest fiber crop. In 1916 the United States produced 11,449,930 bales of 500 pounds each. The "big crop" of 1914 consisted of 16,134,930 bales.

The original home of the cotton plant is not definitely established, but it was probably in the East Indies. Almost everywhere (except in the United States) between 37 degrees north and south latitudes the cotton plant is found growing wild. In the United States cotton is known to have been grown as early as 1621, but in only a small way. A shipment of 3 bags of cotton from Savannah in 1774 was probably the first cotton shipped from this country.

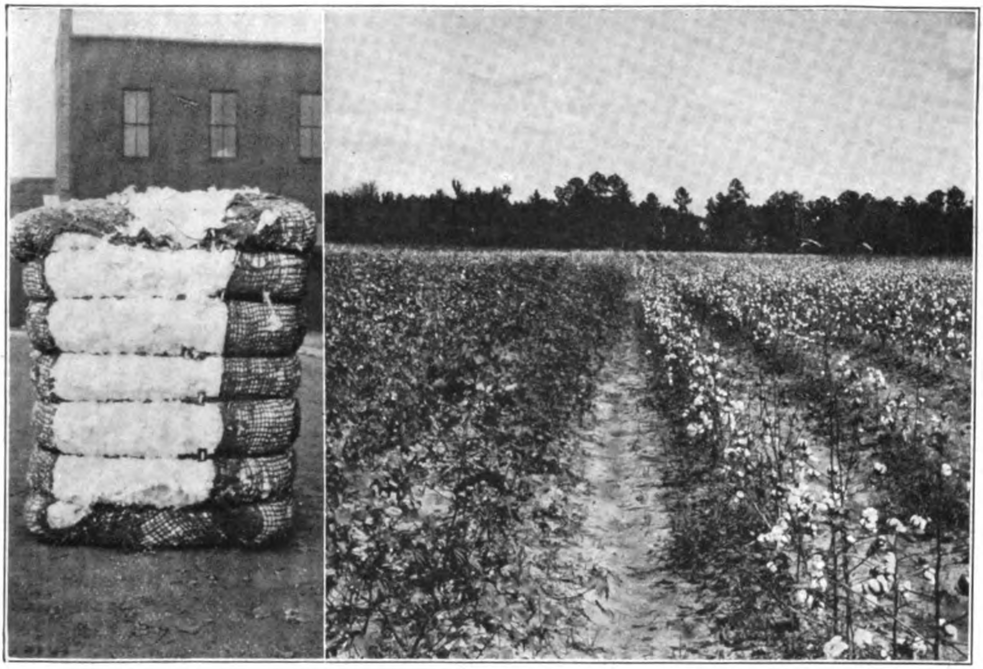
FIG. 339. Cotton plant with leaves removed to show ripe bolls. (N. C. Bulletin 164.)

Kinds of cotton. Most cotton is what is known as *American Upland.* This kind is a native of the American tropics and the leading sort grown in the United States; in fact, all American cotton, except Sea Island and Arizona-Egyptian, is of the Upland species. *Sea Island* cotton, which was found in the West Indies when Columbus discovered those islands, is grown in the United States mainly on or near the coasts of South Carolina and Georgia. The plants make a large growth, but the yields per acre are less than those of upland cotton. Sea Island is costly to pick and gin, but commands a good price. *India* cotton is a native of southern Asia; *Peruvian* cotton is grown chiefly in Peru and Brazil; *Egyptian* cotton is considered as of the same type as Sea Island, although perhaps modified by methods of cultivation and its surroundings.

Upland cotton as grown in the United States averages seven-eighths to 1 inch in length of staple, with some varieties measuring up to 1$\frac{5}{16}$ inches. "Short staple" cotton has a fiber three-fourths to 1$\frac{1}{16}$ inches in length, while "long staple" is anything over that. The trade frequently calls cotton that averages in length of staple 1⅛ inches or more "staple cotton," and that which averages less than 1⅛ inches "short staple" cotton. The official cotton standard of the United States includes the following grades, which cover practically all the white cotton grown in an average season: (1) middling fair; (2) strict good middling; (3) good middling; (4) strict middling; (5) middling; (6) strict low middling; (7) low middling; (8) strict good ordinary; (9) good ordinary. Middling represents the basic grade and it is upon this that market quotations are based. Other names are used to describe the different classes of colored cotton, the differences in color being due to weather or soil conditions.

The plant. Cotton is a tropical plant belonging to the mallow family and therefore related to okra, the hollyhock and some weeds. In the United States, where it is killed by the frost, we know the cotton plant as an annual, but under tropical conditions it is found growing wild as a perennial. The plant, as it is now grown under cultivation, puts forth wide-spreading branches from a stout central stem usually from 2 to 4 feet high but sometimes of greater growth. The longer branches are near the bottom of the stalk. Near the top they are short and light. Pith fills the central stem and branches. The leaves, which are from 3 to 6 inches long and from 2 to 5 inches wide, are alternate and lobed, and all the veins begin at the same point near the base. In most varieties all vegetative parts are covered with very short hairs. A rather tough, strong bark, usually of a brownish color, covers the stalk and stems. The first stage of the fruit, called a *square,* is made up of three bracts with the enclosed flower bud. The flowers have 5 petals. When these appear they are white, pale yellow or cream colored, depending upon the species of cotton. The second day the color changes, and by the third or fourth day, the flowers fall, leaving a small pod. This pod, which is at first about the size of a pea, later grows into the boll which resembles a small hen's egg in size and shape. The matured boll cracks open, disclosing from 3 to 5 divisions each containing seed and lint. When this lint is gathered, ginned and baled, we get the fiber of commerce. The number of bolls on a stalk varies greatly. It has been estimated that, with a good stand, 30 to 50 bolls to the stalk indicate a yield of three-fourths to one bale per acre, except in the small-boll varieties. The latter require 100 to 120 bolls to make a pound of seed cotton. When cotton is ginned the product consists of about two thirds seed and one third lint or fiber by weight.

Climate and soil. Cotton does best in a warm, humid climate and needs from 5 to 6 months of warm weather. However, it can be grown profitably under semi-arid conditions. In the United States most of the cotton is grown south of parallel 37, the southern boundary of Kansas, and east of the 100th meridian, which marks a part of the western border of Oklahoma. In most of this territory the summer temperatures are relatively high, and the annual rainfall is between



The South will, and must, always grow cotton to help clothe the world. (Note the effect of spraying on the right half of this field)

But that it may do so, it must rotate crops and grow legumes and livestock to keep the soil strong and clean

The Southern Farm Empire is just Awakening. Its Possibilities are Almost Limitless

Irrigation water at its source. The storage reservoir of the Salt River Irrigation Project in Arizona

Irrigation water fulfilling its purpose. An irrigated orchard in the Southwest and (inset) a main canal supplying it

IRRIGATION IS A MEANS FOR SOIL IMPROVEMENT, AND ALSO A KEY FOR UNLOCKING THE POSSIBILITIES OF VAST AREAS OF FERTILE BUT ARID SOILS

40 and 50 inches. Cotton needs plenty of rain well distributed throughout the growing season, but dry weather is best at harvest time. Where the spring season is late and the ground cold, cotton does not do well.

There is no typical cotton soil, but one of the best is a medium sandy loam with a clay subsoil. Sandy soils are perhaps the most dependable, but the best crops are grown on clay or silty soils. Rich bottom soils and black lands cause the plants to make a heavy growth but often the harvest is late and disappointing. Fungous diseases and insects frequently cause heavy losses on such lands. In all soils good drainage is important. The climate and soil conditions of southern United States are better suited to cotton growing than is any other equal area in the world.

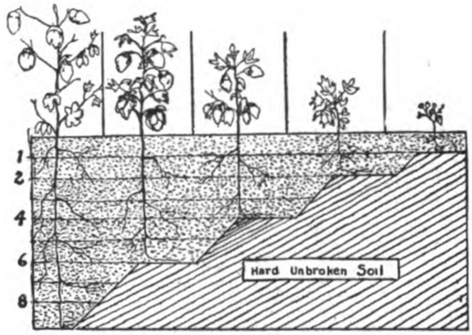


FIG. 340. How deep, thorough cultivation affects the development of the root and therefore of the whole plant. (Hampton [Va.] Bulletin 20).

Growing the Crop

Planting. Fall plowing is desirable except for deep, fertile, moist soils or soils that are of such a nature that there would be a heavy loss from washing during the winter. Deep plowing of fields that have long been in cultivation is recommended. When fields have been plowed deep in the fall it is often best to rebreak the ground in the spring, long enough in advance of planting to allow the seedbed to get good and firm. Just before the seed is planted it is a good plan to freshen up the surface to a depth of 1 or 2 inches. This gives the cotton seed a better chance, and also destroys many young weeds. On well-drained lands, level cultivation is coming more and more to be preferred, but beds or slight ridges are thought best for poorly-drained fields.

Seed should be planted as soon as ground is warm and danger from frost is past. Under favorable conditions it germinates quickly, but cold, wet weather may result in a poor stand. Planting dates vary with the seasons. Average season dates would probably be: Gulf Coast, March 25 to April 25; central part of Gulf States, April 10 to May 1; northern part of Cotton Belt, April 20 to May 15. Much cotton is planted too deep. Except where moisture is lacking or planting is delayed until late in the season, seed should not be covered to a depth of more than 1 inch. Cotton planters, of which there are various types on the market, are used.

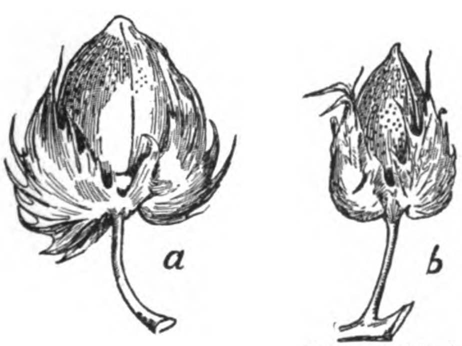


FIG. 341. Typical cotton bolls: *a* American Upland; *b* Sea Island

In planting, the distance between the rows varies, usually from 3 to 4 feet, but a general rule is that the distance between the rows should be slightly more than the height of the plant in average years. Plants make ranker growth on fertile soils than on thin ones, so should not be as close together. An even distribution of the plants, so as to allow for abundant air and sunshine, is desirable. The amount of seed to plant varies, but with good seed, 3 pecks per acre should be ample.

Cultivation. In the first cultivations a harrow is used, and a little later a several-shovel cultivator is one of the best of tools. In a wet season, when weeds and grass are hard to control, it is sometimes necessary to "bar off" the rows with a small turning plow. In later cultivations, during ordinary seasons, weeders and cultivators of various types, including surface sweep, spring-tooth and shovel, are used. Shallow cultivation is the rule; it is continued until the plants become too large to work. The crop is usually "laid by" in July. But a cover crop, if grown, is not planted at this time, as in the case of corn, but later after the cotton is harvested. On the best farms, modern implements and up-to-date methods are greatly changing the work of cotton growing. However, "chop-

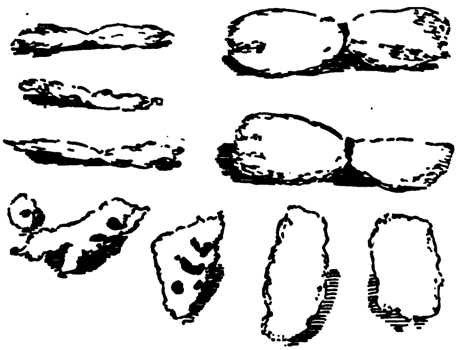


FIG. 342. Good seed cotton (*right*) and a run-out form (*left*). The bottom row shows the locks as picked; in the upper rows the seeds are in the centre with the fibres straightened out on either side. (Farmers' Bulletin 787.)

ping" or thinning out the plants with a hoe, is still necessary as the planters in use drop the seeds in a continuous chain, using many more than are needed. In early planting, a good plan is to chop twice. At the first thinning nearly twice as many plants are left as are needed. A few weeks later the second chopping is made, and the plants thinned so that they are from 15 to 24 inches apart, depending upon variety and soil. One advantage of chopping is that the crop is at the same time given an extra cultivation.

Fertilizers and rotations. Through continuous cotton growing much of the soil has been robbed of its fertility. This does not mean that cotton is a hard crop on the land. Indeed, if only the cotton which finally enters into commerce were removed, there would be taken up less plant food than in the growing of almost any other crop. However, due to a one-crop system, to clean cultivation, to the failure to return plant food, and to the further fact that a highly fertile soil is not necessary to cotton growing, many fields have been allowed to become poorer and poorer. Even when the seed, now such a valuable by-product, was not thought of as having a ready-money value, it was not returned to the land in the form of fertilizer. Finally, when an effort was made to increase yields by supplying plant food, too much reliance was placed upon the sole use of commercial fertilizers which were not always intelligently applied. Greatly increased yields resulted at first, but only to be followed by discouraging results. On the other hand, where approved and systematic crop rotations have been practised and where humus has been liberally supplied, the intelligent use of commercial fertilizers has proved highly profitable on most lands.

In the use of commercial fertilizers the object is to supply, in part at least, food that the plant needs but which is lacking in the soil. On fertile soils, the need is likely to be for a fertilizer that will stimulate the fruit growth, rather than the growth of the plant. Phosphoric acid, for instance, while aiding plant growth, promotes fruitage and hastens maturity of the growing crop. It is this element that is needed for most cotton soils. On thin lands the need is for elements that force growth. This means nitrogen in some form, and here is where the use of legumes—nitrogen gatherers—comes in. Nitrogen can also be bought in the form of commercial fertilizers. As to the third of the essential plant-food elements—potash—many of the stiffer soils of the Southern states are fairly well supplied, except where the potash has been used up through a poor system of farming.

Cottonseed meal is rich in plant food. On rich soils, or where a heavy crop of some legume has first been grown, a good combination for cotton growing is 3 parts of acid phosphate and 1 part of cottonseed meal. On medium soils use 2 parts of acid phosphate; on thin soils, equal parts of cottonseed meal and acid phosphate.

The following amounts of fertilizer (in pounds) have been recommended for cotton: On sandy loam or clay soil when *poor*, cottonseed meal 150, acid phosphate 150; when *medium*, cottonseed meal 100, acid phosphate 200; when *rich*, cottonseed meal 75, acid phosphate 225. On deep, sandy soil of medium grade, 150 pounds each of cottonseed meal, acid phosphate, and kainit are recommended.

The idea is not that plant food must necessarily be applied in these forms, but that the proportions and amounts given are relatively correct. The amount of fertilizer that it will pay to use per acre must depend upon the

FIG. 343. A typical cotton-picking scene

soil, the cost of the fertilizers and the selling price of cotton.

Humus is the great need of most cotton soils. More green manure crops should be grown. Cowpeas, soy beans, velvet beans, or some other legume, should have a place in every rotation. Just which rotation is best will depend upon local conditions, but some rotation should always be used. Farm manures of all kinds should be saved and the plant food given back to the land. Cotton-growing soils should also be handled so as to prevent loss through washing.

Harvesting and Marketing. The harvesting or picking, of cotton is work that requires a great deal of labor. Four or 5 good pickers are required to pick the cotton that one man can cultivate. The amount of cotton that 1 picker will pick in a day varies from 100 to 400 or 500 pounds, the larger amounts being unusual. In order to save the crop in the best condition, 2 or 3 pickings should be made. Ordinarily, picking begins the latter part of August and continues to December 1. Each time as the pickers go through the fields they remove the ripened product consisting of fiber and seed.

Ginning is the second step in saving the cotton crop. Before Eli Whitney invented the cotton gin in 1793 ginning, which consists in separating the lint from the seed, was a slow, tedious and expensive work. Whitney's invention marks the real beginning of the cotton industry in America.

Gins are of two kinds, roller gins and saw gins. The saw gin is used for all short-lint upland varieties. In ginning very long staple varieties, such as Sea Island and Egyptian, the roller gin is used so as not to cut the fiber. The ginned cotton is bound into round or square bales. A standard square bale weighs 500 pounds.

Fig. 344. How the boll weevil injures cotton: *a* the grub or larva in the bud (square); *b* adult weevils on the boll. (International Harvester Co.)

By-products. Formerly cotton was grown solely for its fiber; the seed, looked upon as having no commercial value, was allowed to accumulate in piles about the gins. Now, with the great demand for cottonseed oil, cake and meal, the by-product from every year's crop is valued at millions of dollars. The commercial value of the seed is about one third that of the lint. When the seed reaches the oil mills it is reginned, the fuzz removed by this process being known as "linters." "Cake" and meal are among the most valuable of concentrated feeds for cattle; the oil has many uses and is sold for human food under various names.

Cotton enemies. The cotton plant is said to be preyed upon by some 500 species of insects. Of these the most destructive is the cotton boll weevil, which in the United States first appeared in Texas, in a small district near the Mexican

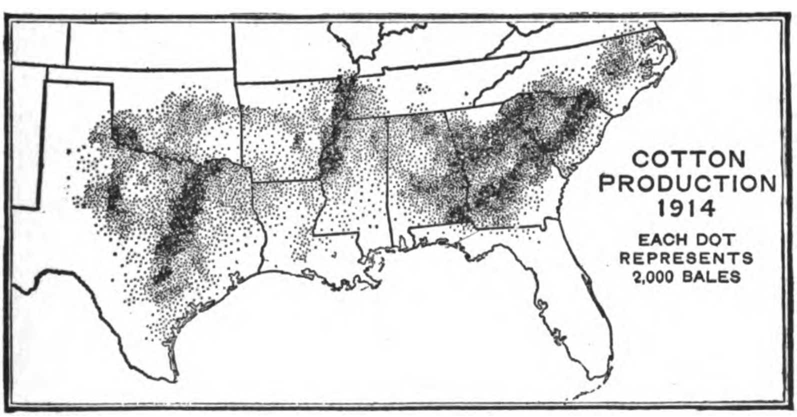


Fig. 345. The United States produces more than half the world's cotton. With improved methods of growing, harvesting, and protecting it from its enemies, this proportion should increase rather than decrease in future. (1915 Yearbook, U. S. Dept. of Agr.)

border, probably in 1892. Since that time this pest has caused losses amounting to millions of dollars and in some sections has made the growing of cotton more costly and has greatly reduced yields and profits. The boll weevil is a member of the beetle family, brown in color, from $\frac{1}{8}$ to $\frac{3}{8}$ inch in length and feeds upon nothing but cotton. Boll worms, cutworms, plant lice, red spiders and caterpillars are among other pests destructive to cotton. Anthracnose, wilt, rust, root-knot and other diseases attack the cotton plant. Clean cultivation, crop rotation and the use of seed from strong, vigorous plants will help control all these enemies. (See Chapters 33 and 34.)

Production. The following figures show the cotton production (exclusive of linters) in 500-lb. bales (or equivalent) by states for the year 1916: Alabama, 533,084; Arkansas, 1,134,033; California, 43,620; Florida, 41,449; Georgia, 1,820,939; Louisiana, 423,802; Mississippi, 811,794; Missouri, 62,699; North Carolina, 654,603; Oklahoma, 823,526; South Carolina, 931,830; Tennessee, 382,422; Texas, 3,725,700; Virginia, 27,127; all other states, 13,604.

The world's production of cotton (about 25,200,000 bales) is taken care of by practically four countries. The United States produces 58 per cent of the world's crop; India 13 per cent; Egypt about 6 per cent; Russia about 3 per cent; and the rest of the world the remaining 20 per cent. The United States leads also in exports of cotton with close to 10,000,000 bales, India coming second with less than 2,000,000. Great Britain is the heaviest importer to the extent of about $4\frac{1}{2}$ million bales; Germany comes next ($2\frac{1}{2}$ million) and France, Japan, and Italy lead the others.

Hemp

Hemp is one of the oldest of fiber-producing plants and also the name given to the fiber. The plant is an annual, growing each year from the seed. It reaches a height of from 7 to 10 feet when drilled or broadcasted and grown for fiber, and 9 to 15 feet when cultivated for seed. The hollow central stalk, which is rather 4-cornered and fluted with nodes (joints) 4 to 20 inches apart, varies from one fourth to 2 inches in thickness. There are many branches, unless the plants are crowded in growth, when the only branches are near the top of the stalk. Leaves are dark green, 2 to 6 inches long and $\frac{3}{8}$ to $\frac{3}{4}$ inch wide. Around the hollow centre of the stalk is a layer of pith or thin-walled tissue; outside this is a layer of wood made up of hard, thick-walled cells. The next layer is made up of the hurds or fibers, and in the best fiber-producing varieties, this is very thin. Some of the fibers are branched, some terminate at each node, and some extend the length of the stalk.

Where grown. Hemp is grown in various parts of Europe, Asia and of North and South America. It is probably native to China or the region between the Himalayas and Siberia. In the United States it was first grown in the early Puritan settlements of New England, and soon introduced into Virginia; it was grown in Kentucky as early as 1775. In 1909, according to the Thirteenth Census, the leading hemp-producing district in the United States was the blue-grass region of Kentucky, which state produced 6,420,232 of the 7,483,295 pounds grown in this country. Nearly all of the hemp grown in Kentucky comes from seed of Chinese origin, the first having been imported in 1857. Hemp is one of the oldest fiber-producing crops, and formerly was one of the most important. Since the beginning of the 20th century, however, there has been a decline, owing to (1) scarcity of labor; (2) lack of labor-saving machinery; (3) larger profits from other crops; (4) competition of other fibers; and (5) lack of widespread knowledge of the crop. Between 1899 and 1909 the hemp crop of the United States declined more than 4 million pounds.


FIG. 346. Shocks of seed hemp curing in the field

Uses and varieties. Hemp is grown for

(1) the fiber obtained from the bast; (2) oil taken from the seeds; and (3) resinous drugs extracted from the flowers and leaves, but in the United States the greater part is grown for fiber. There are few recognized varieties. Hemp is cross-fertilized, so mixes easily. Types also vary on different soils. Hemp shows a decided tendency to "run out," partly because poor fiber-producing plants are generally heavy seed-bearers with early-maturing tendencies. For this reason seed selection and plant breeding are necessary. Kentucky growers generally prefer small, dark-colored seed.

Requirements for growing. Hemp requires a humid climate and does best where the temperature ranges between 60 and 80 degrees during the growing season. When grown for fiber there should be 4 months free from killing frosts, although hemp will withstand some frost. Grown for seed, the frost-free season should be 6 weeks longer. A plentiful supply of moisture is required, especially when the plants are small, yet good drainage is important. On heavy clay soils excessive rainfall may result in the loss of the young plants. A drought late in the season has a tendency to hasten maturity and to reduce the growth. In the Kentucky hemp-growing districts, the total rainfall for the 4 months growing season is 15.6 inches, well distributed. As hemp makes a comparatively rank growth in a rather short period, the best soil for it is deep, fertile, and well supplied with humus.

Soils not naturally fertile must be made so for successful hemp growing. For this purpose there is nothing better than stable manure applied to the preceding crop. Hemp is not especially hard on the soil, and leaves the ground in good condition for other crops.

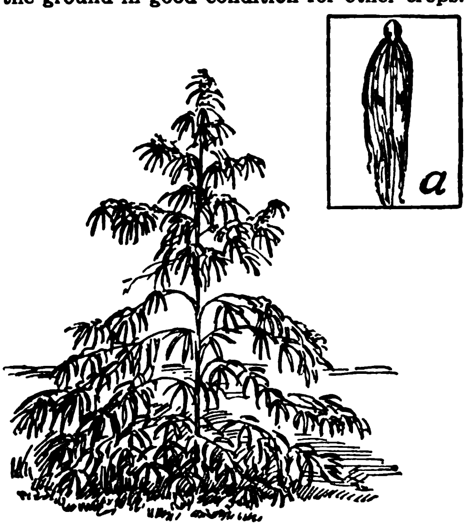


FIG. 347. A hemp plant and (*a*) a bundle of hemp fibre

FIG. 348. Spreading hemp for retting. (1913 Yearbook, U. S. Dept. of Agr.)

In Kentucky it is grown on a clay loam, where outcroppings of limestone are common.

As a seed crop. For seed hemp is planted about March 15 to April 20, on well-prepared ground. Rows are laid off 4 or 5 feet apart and from 5 to 7 seeds are put in each hill. One to 2 quarts of seed will plant an acre. Three or 4 cultivations should be given. When seed plants are fully mature they are cut, usually with corn knives, after which they are set up in loose shocks and left for 2 or 3 weeks or until dry. The shocks are then placed on tarpaulins and the seed is beaten out with sticks, then cleaned by means of a small fanning mill or larger mill. A fair yield is 16 to 18 bushels per acre.

As a fiber crop. Hemp is usually drilled in on land plowed deep in the fall and well prepared in the spring at the rate of 3 to 4 pecks per acre (more for rich soil and less for poor). Seed should be sown as uniformly as possible and not too deep—from $\frac{3}{4}$ to 2 inches depending upon the soil. A good plan is to drill in both directions, using one-half bushel each way. In Kentucky, seed sown in April generally gives best results. Like wheat or oats, hemp sown for seed requires no attention until it is ready to harvest, which is usually in September. For the best fiber, hemp should be cut when the staminate plants are in bloom.

Harvesting. In Kentucky a part of the hemp crop is still cut by hand, like corn. Mowers with sweep-rakes, and mowing machines equipped with a wooden bar about 4 feet above the cutting level, so as to bend over the hemp, are sometimes used. There are also special hemp-harvesting machines. *Stacking* requires care, as the stalks must be kept straight with the butts even. The hemp to be stacked is first bound in bundles, which are placed in shocks to cure until they will not heat in the stack. Stacking is said to improve the quality of the fiber, and to make retting less difficult.

Retting is the process by which the gums which surround and bind together the fiber are dissolved and removed. The common methods of retting are (1) dew retting, and (2) water retting. Steam retting has also been tried in Japan. Dew retting, practised almost exclusively in this country, consists in spreading the hemp, only a few stalks deep, over the ground where it is left exposed to the

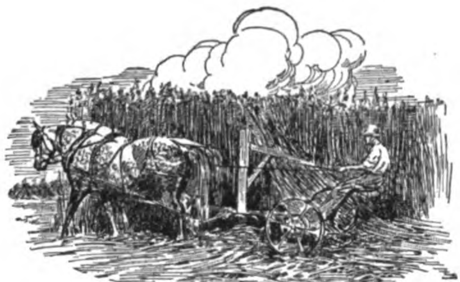


FIG. 349. Harvesting hemp with a mower. Note the arm designed to bend it over ahead of the machine. (1913 Yearbook, U. S. Dept. of Agr.)

FIG. 350. Breaking hemp by hand. (1913 Yearbook, U. S. Dept. of Agr.)

weather until the fiber can be easily separated from the woody portion. Water retting consists in putting the hemp in water, usually in a pond, lake or stream.

Breaking **(of the inner woody shell) is done either by means of a hand or a machine brake. The hand brake, long in use, consists of 3 boards set edgewise and farther apart at one end than at the other. Into the two long openings two other boards, with sharpened edges, are worked up and down, while the hemp, laid crosswise, is moved from the wide end toward the narrow end of the brake.**

Scrutching **is the removal of the woody portions after breaking has been completed. Before the hemp is removed from the farm, it is usually packed into bundles weighing about 200 pounds.**

Hackling **is an important step that comes after the hemp has been removed from the farm, sold, stored and sorted. In hackling, the fiber is shaken out to its full length, then combed out by being drawn across a coarse hackle, first one end and then the other. A hackle is a kind of comb or brush consisting of several rows of steel pins or teeth about 7 inches long, ¼ inch thick and 1 inch apart. The use of such a hackle produces "single-dressed hemp"; when a second and finer hackle is used, the product is "double-dressed hemp."**

For shipment, hemp is made into bales about 4 x 3 x 2 feet. A bale of tow (the fiber from broken or tangled stalks and fiber beaten out in cleaning the best straight hemp) weighs about 450 pounds. Rough hemp weighs about 500 pounds per bale; single-dressed, 800 pounds; double-dressed, 900. The yield of hemp in the United States averages about 1,000 pounds per acre.

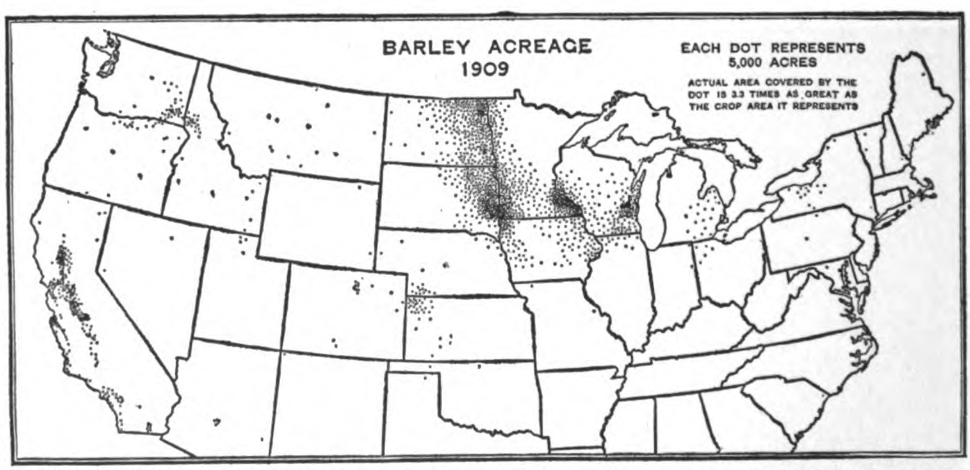


FIG. 351. With the increased demand for wheat to be shipped to Europe, barley and other cereals gain new importance. For cultural methods, see page 227. (1915 Yearbook, U. S. Dept. of Agr.)

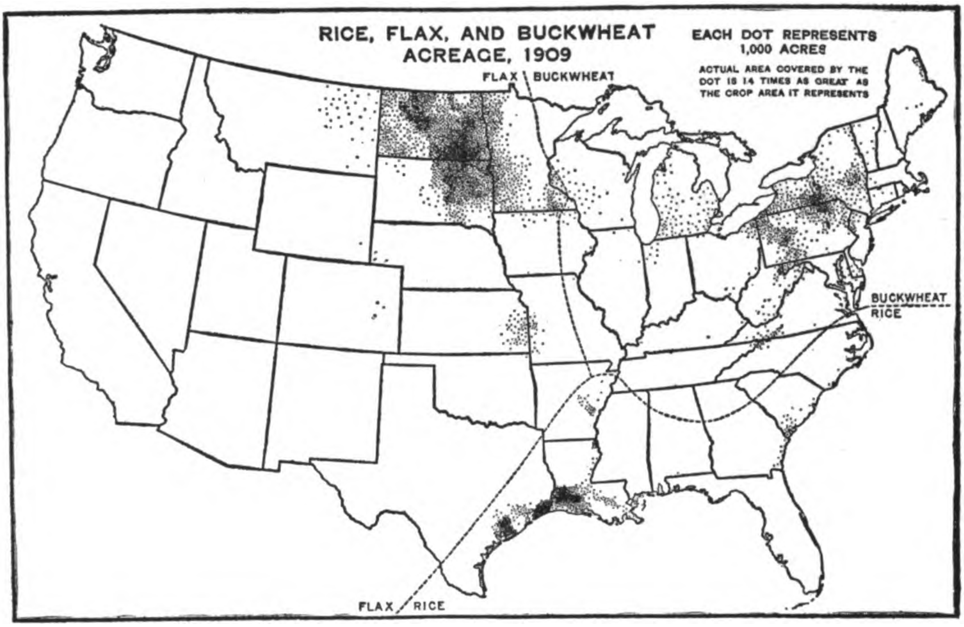


FIG. 352*a*. These are all distinctly localized crops. Flax is grown mainly for seed in this country. Rice demands both warmth and abundant moisture, making irrigation practically essential

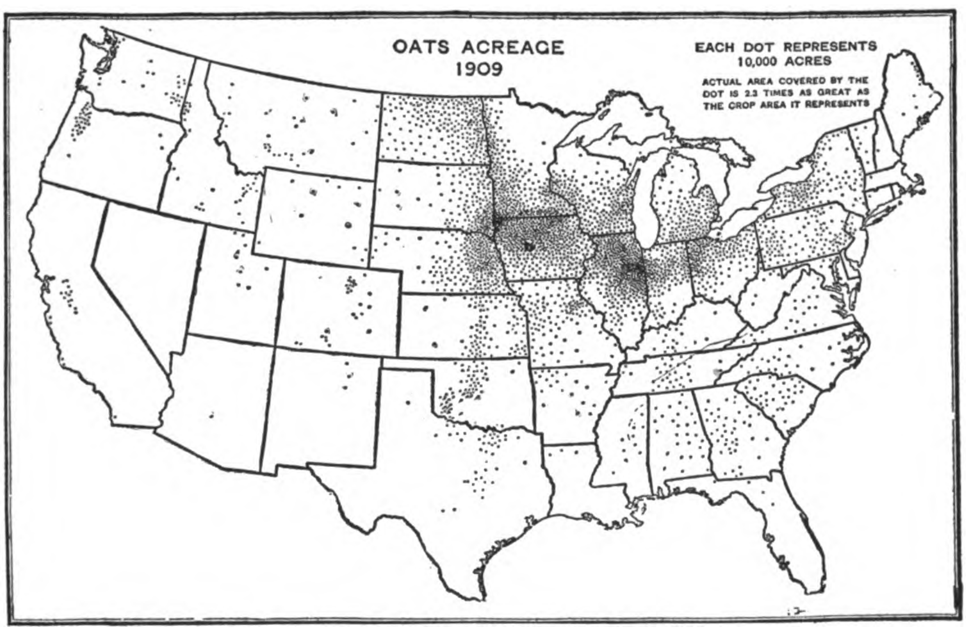


FIG. 352*b*. This map refers to that part of the crop cut for grain. A good deal is harvested for hay or green forage, especially in a mixture with Canada peas. (These maps from 1915 Yearbook, U. S. Dept. of Agr.)

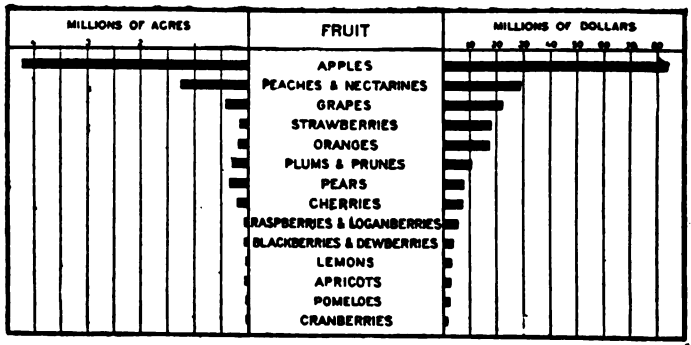


FIG. 353. The relative importance of different fruits in the United States. (1915 Yearbook, U. S. Dept. of Agriculture)

CHAPTER 27

Fruits in America and How to Grow Them

By PROFESSOR M. G. KAINS, *who has prepared also the material on the Principles of Fruit Growing, and who has more than a speaking acquaintance with most of the subjects discussed here. In view of the large number of fruits that are or can be grown in this country, either commercially or for home consumption, and of the different methods that have to be employed in raising them in different sections, it is clearly impossible to give all the information about each one, that every grower in every part of the country could desire. Moreover, the wealth of available books and bulletins on fruit growing, especially its local problems, make such a course unnecessary and unwise. The aim has been, therefore, briefly to lay down the principles according to which these fruits are grown; and to tell where and how they can be made to succeed, and to what extent and for what purposes they are worthy of cultivation. With this foundation and the more detailed information obtainable from nearby successful growers and experiment stations, any farmer should be able to steer along the deep, wide channels into the safe, still harbors of profitable fruit growing.*—EDITOR.

ALGAROBA, *see Carob.*

ALLIGATOR PEAR, *see Avocado.*

ALMOND, a peach-like tree, probably a native of the Mediterranean region, cultivated for ages for its nuts. Certain varieties with bitter kernels (grown almost entirely in foreign countries) are used for making flavoring extracts and prussic acid; those with sweet kernels are eaten raw, in candies, etc. The latter include both hard-shelled kinds which are not grown commercially, and soft-shelled sorts, some of which (the "paper shells") have shells that can be broken between the fingers.

Varieties now grown in America are mostly seedlings which originated in California. Of the 25 or 30 kinds that have been tried commercially, the following are the most widely grown in the order named, the first three comprising 75 per cent or more of the total acreage: *Nonpareil, Ne Plus Ultra, I X L, Drake, Texas Prolific,* and *Languedoc.*

Where grown. Being more tender than peach or prune, and having an extremely early blossoming habit, the almond can safely be grown only in mild climates, California being the principal region of production. The 1910 census reported 6,692,513 pounds from that state, 33,759 from Arizona, and 67,267 from all other states. In California almond growing began about 1850 and has had many ups and downs, due mainly to the action of spring frosts, the unsatisfactory bearing qualities of some varieties and the fact that some are self-sterile. These, of course, require the planting of other varieties among them. Nurserymen can inform growers as to which they are. The almond does best on deep, light, well-drained loams, even though these may be rather poor for other fruit trees, and is therefore often planted on the higher and drier lands in California. If placed on wet lands the trees soon die. Trees ordinarily begin to bear about the fourth year, yielding profitable crops about the sixth or eighth. They continue in bearing for 10 or more years and, unless the blossoms are frosted, yield regularly each season. The yield per acre may range from 800 to 2,000 pounds; with trees set 20 feet apart, this would mean from 8 to about 20 pounds per tree.

How to grow it. Trees one year old in the nursery row should always be planted; older ones are unsatisfactory. The improved va-

iety should meanwhile have been budded on sweet or bitter hard-shelled seedlings during their first summer. Two favorite practices are to plant while dormant during the winter, or after one season's growth has been made from the bud. Then the young trees are cut back to form heads about 1 foot from the ground. The following winter the 4 or 5 main branches are cut back to make them branch again within a foot of the main trunk. As far as possible these main limbs are spaced rather far apart so as to prevent splitting later, and are distributed around the trunk so as to make the head symmetrical. Similar pruning and training the second winter in the orchard encourages the formation of a vase-formed head. Enough branches are left in the interior of the head to fill the space without crowding. The third summer's growths are usually left for fruiting with only enough cutting to prevent crowding. Similar thinning is done annually thereafter, else the top of the tree will become too dense and the fruit bearing will be injured. In other respects

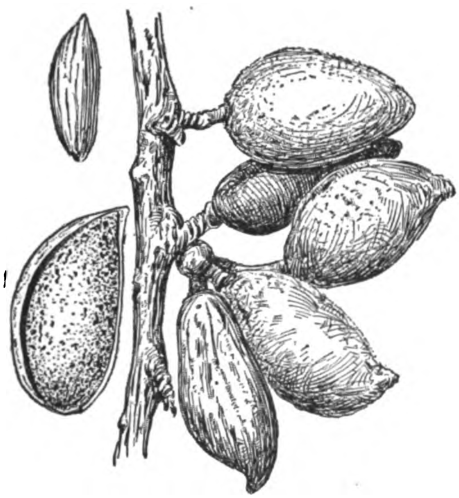


FIG. 354. Cluster of almonds as grown. At *left*, one with the husk partly removed; and *above*, a kernel

orchard management, including control of insect pests and diseases, resembles that of the peach (p. 341).

Harvesting and marketing. In harvesting, much depends on the climate. Where the air is dry in summer, the hulls open readily and the clean nuts require no processing to make them marketable. In moister areas the nuts become discolored and have to be blanched; sulphur fumes are generally used for this purpose. Unless the nuts are dry, sulphuring injures the flavor of the kernels; it also kills the germ, so nuts for planting must not be sulphured. Usually nuts to be sulphured are dried in the sun for a few days after being gathered, moistened on the outside with a mist-like spray or steam jet, then treated with the sulphur fumes. Rain-stained nuts, however, cannot be cleaned by sulphuring, so they are cracked and the kernels sold for confectionery and "salting." Since immense quantities of nuts are used in these ways smooth, symmetrical plump kernels are important. "Philopenas," being irregular, are not wanted; hence, varieties which produce few such twins are preferred by growers. Another point to bear in mind is the proportion of "meat" to shell; the larger this is the better, provided the shell is not so weak that the nuts are injured by ordinary commercial handling or so thin that sulphuring will injure the flavor. Some varieties drop their nuts readily; others have to be beaten with light poles. In the former case the nuts are generally free from parts of hulls; in the latter the hulls often cling and must be removed by almond hulling machines.

AMALUNGULA, see *Caraunda*.

ANNONA the botanical name of a group of tropical and subtropical trees and shrubs, many of which bear fruits highly valued in warm countries for home use and local trade. Some of the species are cultivated in parts of the Gulf States and westward to California, usually upon loamy soils; others have become naturalized in the Florida Keys and nearby mainland. Most of the cultivated kinds begin to bear when 3 or 4 years old. The fruits must be picked as soon as mature to avoid their falling and bruising. A few days on shelves bring them to perfection for eating. If to be shipped, they must be packed in soft, well-ventilated material such as excelsior. Among the most important species are the Sour-sop, Graviola, or Corosol; the Negro-head, Toreta, or Soncoya; the Pond-Apple, Mamin or Cayul; the Cherimolla or Cherimoya; the Jalisco; the Custard-Apple or Bullock's Heart; the Sweet-Sop, Sugar-Apple, or Atta; and the Ilama.

APPLE. A native of southeastern Europe and nearby Asia. This plant has been so improved and so many varieties have been developed that it has become the leading home and commercial tree fruit of temperate climates, if not of the world. Like the pear, peach, cherry, and several of the popular bush fruits, it is a member of the rose family, in which the fruit is not merely a seed vessel, but primarily a thick, fleshy, edible pulp. Roughly speaking our familiar red, yellow, and green varieties all represent highly improved descendants of the common wild crab of the open fields.

Apparently two distinct species are the ancestors of our cultivated apples. One is a round-headed tree with thick, fuzzy, short-stemmed leaves and rather dense clusters of woolly-stalked flowers as in most common apples; the other a more wiry-growing tree with glossy, long-stalked leaves and rather

open clusters of flowers, as in many crab-apples. Two species, natives of the American prairies, have been improved to some extent, but so far have given very few varieties. They are useful in unfavorable climates where better kinds fail. The name apple is also applied to many other fruits such as Mammee apple, May apple, Star apple, etc.

Where grown. While certain varieties succeed nearly as far north as Newfoundland on the Atlantic Coast, and considerably farther north on the Pacific Coast; and while certain other varieties do well as far south as the mountains of Georgia and Tennessee, and in California and New Mexico, the apple does best in the more temperate parts of the United States and Canada. One important section extends from Nova Scotia to New Jersey and westward to Lake Michigan, with an extension southward through the Pennsylvania mountains to South Carolina. Others include the Ozark and the Plains regions, the mountain valleys from Montana to New Mexico and the Pacific Coast from Oregon northward but including also parts of California. Except in the highlands, the states bordering the Gulf of Mexico and the warm southwestern states are not adapted to the apple.

Not only is the apple the most important commercial fruit of the world, but the United States and Canada are the most important apple-producing countries; Australia and New Zealand together perhaps rank second.

Production. It has been estimated that a full crop in North America is 100,000,000 barrels. The census of 1910 shows that 151,322,840 trees of bearing age and 65,791,848 young trees were in American orchards, and that the previous autumn the former produced 147,522,318 bushels valued at $83,231,492. While yields differ widely in different sections and in different years, the average for the whole country is fairly constant as shown by the following figures from the 1916 Yearbook of the Department of Agriculture:

YEAR	PRODUCTION BBLS. OF 3 BU. EACH	FARM PRICE CENTS PER BU.
1910	47,213,000	89.6
1911	71,340,000	72.1
1912	78,407,000	66.3
1913	48,470,000	98.1
1914	84,400,000	59.4
1915	76,670,000	69.0
1916	67,415,000	91.8

The 10 leading apple states and their 1916 yields were, according to the Yearbook: New York 12,600,000 bbls.; Pennsylvania 6,207,000; Virginia 4,433,000; Michigan 4,160,000; West Virginia 3,344,000; Ohio 2,867,000; Missouri 2,700,000; North Carolina 2,358,000; Kentucky 2,147,000; California 1,918,000.

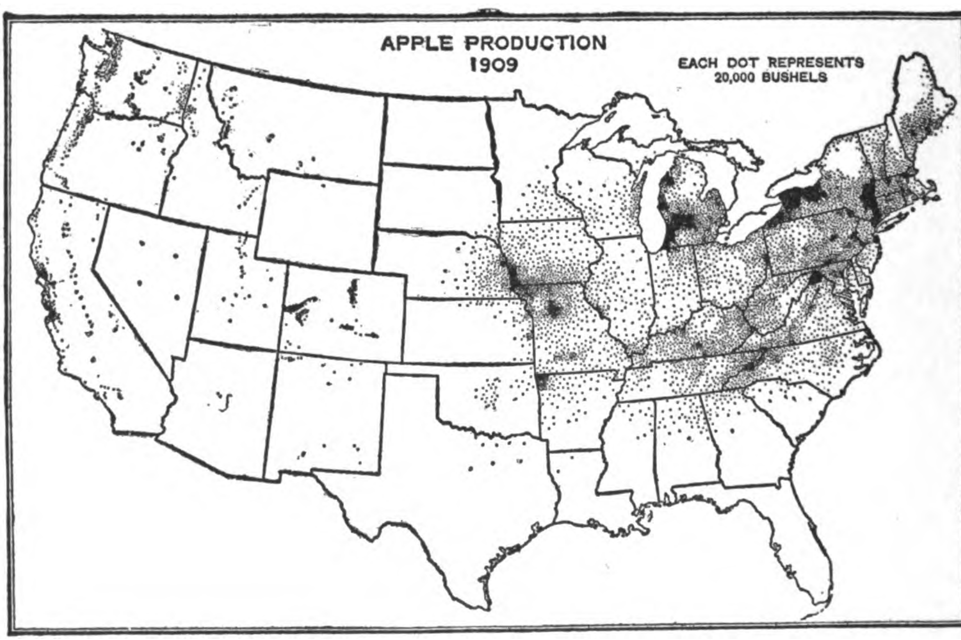


FIG. 355. The apple is grown in the cooler humid sections—either the northern latitudes or the higher elevations farther south. (1915 Yearbook, U. S. Dept. of Agr.)

Fruiting age. Varieties differ widely in the time they come into bearing, the amount of fruit they bear at various ages, under varying treatment and in many other ways. Some may begin to bear within 2 years after transplanting as two-year-old nursery trees; many others require 8 or 9 years. Rarely does an apple tree begin to yield a profitable crop earlier than the fifth year after it starts to bear. This time is much more likely to be lengthened than shortened by methods of management, especially pruning. The Oregon Experiment Station has shown that trees may be prevented from bearing by unwise pruning which "throws them out of the bearing habit."

Yields. It is impossible to say how many bushels an apple tree should bear at a given age, because variety, climate, soil, enemies, and other factors influence yield. Records from full-grown trees show yields of 15 to 20 barrels from Northern Spy, 25 to 30 from York Imperial, and 20 to 25 from Baldwin, but these are exceptional. Probably an average for commercial varieties lies between 10 and 15 barrels. But there are countless varieties—so called "shy" bearers—that yield far less than this. Therefore, when choosing varieties for business purposes, it is well to look up reliable records as to bearing habits. For the home orchard such information is of minor importance because varieties for home use should be chosen more upon the basis of quality, whether they are to be eaten raw or cooked. Another point is that, whereas the commercial orchard should generally include not more than 3 to 5 varieties, the home orchard should have many, ripening in succession so as to cover the entire season; these should include both dessert and cooking, sweet and tart kinds so as to suit all palates and purposes. While data of this kind may be found in nurserymen's catalogues, government and experiment station publications and books on fruit growing, special attention should be given to the varieties known to be successful in the neighborhood, and to avoid or at least plant sparingly novelties and varieties not fully tested locally even though they may be famous in some other locality. The following list is merely suggestive:

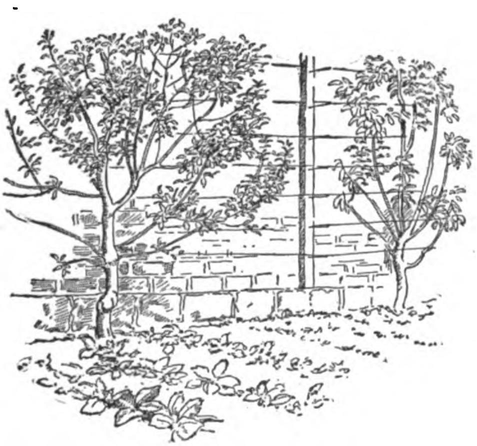


FIG. 356. Dwarf apples trained on a wall, combined with strawberries in the foreground

APPLE VARIETIES FOR VARIOUS PURPOSES

NAME	USE D-DESSERT G-GENERAL PURPOSE, C-COOKING	PROBABLE EARLIEST BEARING AGE
Baldwin	G C	8
Ben Davis	C	4
Dominie	G C	5
Oldenburg	D G C	2
Early Harvest	D G C	4
Early Strawberry	D G	10
Esopus	D G C	9
Fallawater	G C	5
Fall Pippin	D G C	9
Fameuse	D G	5
Golden Russet	D G	9
Gravenstein	D G C	8
Green Newtown	D G C	5
Tompkins King	D G C	5
Maiden Blush	D C	4
Mother	D	9
Munson Sweet	G C	5
Northern Spy	D G C	9
Peck	D G	7
Pomme Grise	D	5
Primate	D G C	3
Red Astrachan	D G C	5
Rhode Island	D G C	5
Rome	C	2
Tolman Sweet	C	8
Twenty Ounce	G C	5
Wagener	D G	4
Westfield	D G	9
Williams Favorite	D G	3
Winesap	D G C	5
Yellow Belle-flower	G C	9
Yellow Transparent	D G C	4

Propagation. In order to get varieties true to name, apples are grafted or budded in seedling apple-tree roots, and grown in nurseries one or two years (preferably not longer). Taking the country as a whole, budded trees are generally preferred to grafted stock but in the upper Mississippi basin, the demand is for trees grafted on small pieces of root mainly because under this system the improved variety tends to develop roots of its own. Such "own-rooted" trees are supposedly hardier than when long pieces or entire roots are employed. The conclusion drawn by several experiment stations is that none of the

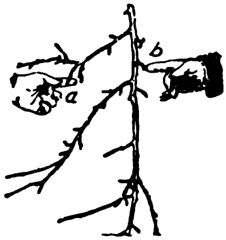


FIG. 357. An apple twig showing a leaf bud (*a*) and a fruit or blossom bud (*b*).

methods has a striking advantage over any other. It may be advisable to get rid of the seedling root altogether by using the shortest possible pieces and cutting them off at the time of transplanting, provided that the roots have developed above the union of stock and scion. While trees two years old or older were formerly planted, one-year stock is now more popular mainly because the heads may be formed where wanted. Older trees may have been headed too high in the nursery and a change may mean too much trouble and loss of time.

Dwarf Trees. Apples may be readily dwarfed by grafting or budding them on Doucin or Paradise apple stocks which are varieties that naturally grow much smaller than others. While dwarf apples are very popular in the old world (where they are often trained on walls and trellises) mainly because of the limited land area, they are very little grown in America because such methods are too fussy, and land is abundant enough to make such intensive methods unnecessary. Investigations made by the New York Experiment Station have shown that the many objections to dwarf apples for commercial purposes have been well founded. Unless treated as dwarfs and trained, severely pruned, thinned, etc., they are likely to become top heavy and blow over. While they bear earlier than standard trees, they are also shorter lived. They may, however, prove really useful in the home garden where there is limited space and where the owner likes to and can do a lot of coddling. Dwarf stock trained as dwarfs must not be confused with merely *low-headed* standard trees, which offer many advantages over high-headed specimens in both commercial and home orchards.

Fruit-bearing habits. One of the most important points to note in apple production is the habit of fruit bearing. While varieties differ considerably among themselves, and also when grown under different conditions, they usually bear on spurs or short growths which often become gnarly with age. These spurs begin to develop usually between the fourth and the eighth years—sometimes earlier, often later in poorly managed trees. At first, they are little stubs which end in a large round-headed bud. This bud develops a cluster of flowers surrounded by leaves. One of the flowers develops into a fruit (sometimes 2 do so) and thus the stem is prevented from growing in its original direction. While the fruits are developing, a bud is also being developed at one side of the little spur. The following year this bud normally develops a short stem—no blossoms—in a different direction, and at its tip appears a rounded bud for the third season's bloom. This peculiarity accounts for the gnarliness of the spur and the "off" and "full" years of apple cropping. By keeping this habit of fruit production in mind, the grower can prune and train his trees intelligently, and secure fruit where he would probably fail otherwise.

Planting. In planting apples for commercial purposes, it is not considered advisable to mix them in with other kinds of fruit, mainly because of the differences necessary in handling the different kinds of trees. In the home orchard, this objection has less weight because the grower can (or should be able to) give the better care such arrangement always demands. The distance to allow between trees varies largely with the style of growth. Perhaps the most serious mistake in the planting of 25 and more years ago was too close planting. The results are excessive height, difficulty in pruning, spraying, and harvesting. None but dwarfs should be set closer than 35 feet apart, and this distance should be for only small-growing varieties. Most commercial orchardists favor 40 feet for such trees and 50 feet for the spreading varieties. When the trees are full grown, they will use all this space. In order to reduce the cost of growing to the bearing age, an orchard so planted, low-growing crops such as tomatoes, potatoes, cabbage, and turnips may be grown among the trees. Even corn may be grown the first year or two. In some parts of the West, apple trees are planted in hexagons because this method is supposed to make the most economical use of the ground. The plan is so much more difficult to work than the "square" plan, that the latter is usually preferred in other parts of the country.

"Fillers." The so-called "filler" plan of growing an orchard—planting long-lived and short-lived fruit trees alternately with the intention of cutting out the latter when the former need the space—is not to be recommended because not one man in a hundred will have the "nerve" to cut out the fillers at the proper time. The only safe way to use

FIG. 358. Three fruit crops on the same ground: standard apple trees, peach trees as fillers and bush fruits between the rows. This calls for generous soil feeding.

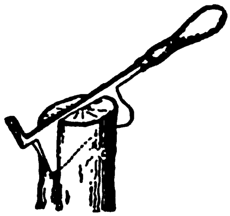


FIG. 359. Splitting the stock in making a cleft graft

the filler system is to increase the distance largely between the trees; for instance, instead of setting them 20 feet apart so that when half are cut down the other half will stand 40 by 40, set them 30 feet apart so that, when the cutting is done, the trees remaining will stand 60 by 60 feet. The fillers should always be short-lived, erect-growing varieties. Those that are to remain may be long-lived, spreading kinds. Where the filler system is practised, commercial growers do not favor planting peaches with apples.

Suitable soils. Any soil that will yield good paying crops of corn, potatoes, or wheat should be good for apples, provided other conditions are favorable. Preference should be given to rolling or rather elevated sites because of better drainage. Spring planting has been, perhaps, the more popular, but fall planting offers so many advantages that it is rapidly gaining.

Tillage. While apple trees may do fairly well in uncultivated land, the experience of thousands of commercial growers proves that they do better when the land is properly tilled. About the only exception to this general rule is the so-called "sod-mulch" treatment, which may give good results where there is a surplus of soil water. In this system the grass is mowed and is either allowed to lie where it falls, or spread around the base of the trees.

Fertilizing. Where the soil is already strong, proper handling may prevent the necessity of applying commercial fertilizers, at least until the trees reach bearing age. The amounts of each kind of fertilizer to apply must then be determined by the behavior of the trees. Mature orchards in full bearing should generally have an annual dressing of fertilizers. Applications of lime, about 1,000 pounds to the acre every 4 or 5 years, are often very helpful.

Renovating. Many old apple trees that have declined in bearing through neglect or improper management, need not be cut down but may often be reclaimed. First, all the dead wood should be cut out; second, all diseased limbs, and third, branches that interfere seriously with each other. If there are many of these and also much other living wood to be removed, only about a third should be taken out the first winter. The remainder may be cut during the next two winters. This plan will upset the balance of root to top far less than if it is done all at once. In reducing the living wood, the fruit spurs and water sprouts must be specially noted. The former may well be left untouched until the third or fourth year, to show what they can do; the latter, if well placed, may be saved to fill in gaps and develop new bearing parts. Trees with many water sprouts always have good roots; and are easy to work over.

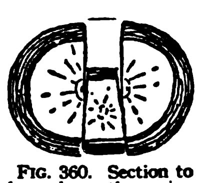


FIG. 360. Section to show how the scion should be inserted n the stock in cleft grafting.

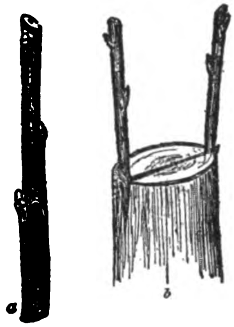


FIG. 361. Cleft grafting, (*a*) scion; (*b*) stock split and two scions in place.

Whenever a large limb is to be removed, first cut upward from below about 15 inches away from the main trunk or limb. When the tool sticks, a second cut made from above at the same point will allow the branch to drop without splitting or tearing the remaining parts. Then the stub must be removed by a cut even with the remaining branch. The closer it is the quicker it will heal. The heart wood of large wounds may be sparingly painted with creosote but care must be taken to avoid touching the living wood with this stuff because it would thus be killed and the healing would be retarded. Authorities do not agree as to the need of covering wounds with paint or tar.

Old orchards often suffer for lack of moisture, because of the sod that has grown up around them. They must not be plowed deeply at first because too many roots would be cut, but 3 or 4 inches deep the first time is usually safe. Before or after plowing, 20 tons of old manure may be disked into the surface and the land kept cultivated till midsummer when a cover crop may be sown. The second spring it may be plowed an inch or two deeper.

If the trees are of undesirable varieties, they may be top-grafted by the cleft method in spring. Such grafts should begin to bear the third or fourth year after, that is, 4 or 5 years sooner than


FIG. 362. Pressing the head on a barrel of apples to insure a firm, tight pack.

young trees. Several varieties may be grafted into the same tree.

Harvesting. In gathering apples, many fruit growers pick too early. While overripe fruit loses quality quickly and rots, immature fruit lacks flavor and sweetness. The best plan perhaps for all cases is to let the fruit hang on the trees till properly colored and of at least average size for the variety. The flesh should be firm but not hard. In the actual picking, the apples should never be removed by a straight pull because this will either break the fruit spur upon which future fruit must be borne, or perhaps pull the stem out of the fruit itself. One good way is to twist the apple so the stem will separate from the fruit spur at the point of union. Another way is to place the thumb or finger against this point and either bend the fruit backward or push the stem until it separates from the spur. Just as with more tender fruits, special care should be taken to avoid bruising.

Grading. Good business methods require that all fruit be graded. Also certain laws of various states and of the National government cover this point and also packing, branding, etc. Every fruit grower should be posted on these points. Helpful suggestions can be gotten from many experiment station bulletins.

Box packing. In the West, boxes holding about 1 bushel have for years been used instead of barrels for shipping apples; in the east, though the barrel is still the leading package, the box is growing in popularity. It is claimed to be a convenient sized package for the small family; it looks well; the fruit of even soft varieties such as Northern Spy, Yellow Bellflower, Fameuse, McIntosh, and Wealthy, if properly packed in it, reaches the consumer in perfect condition; it is convenient to handle, pack in cars and store in quantity. Boxed fruit keeps better than in the barrel and enables the grower to reach the consumer with his own brand and thus increase the demand for his fruit.

The barrel does not permit of such perfect packing or handling, and is, therefore, used by growers who grade their fruit less carefully, aiming to sell the largest possible part of their product and catering to the general public. Boxes are used by men who make fine appearance and high quality their goal, and cater to the special customer. The question is then less one of the kind of package than the character of the fruit. The man who aims for the box trade must handle his orchard and his fruit more skilfully than he who is satisfied with the barrel trade.

Storing. For storage in home cellars, moderate quantities may be spread 3 or 4 deep on the clean earth floor. Mid-autumn varieties have been kept thus until mid-winter, and ordinary winter varieties until late spring. It is good management to use the fall varieties as they mature rather than to make them last unduly long. In storing larger quantities, the barrel is most popular because it not only checks drying, wilting, and rotting, but because its shape allows for enough ventilation on all sides. Whatever method is adopted, the cellar must be unheated, frost-proof and provided with plenty of small windows. During fall, early winter and spring, these must be opened at night to let in the cold air, and closed in the morning to hold this cold air in. At all times, the temperature should be kept as near the freezing point as possible. Two or three degrees lower will do no harm.

Marketing. When apples are to be shipped to market, the standard barrel of the state or the nation should be used. Before starting to pack, see that one head is securely nailed on, with each nail slanted so it will not puncture the fruit. Turn this head down, loosen the hoops and remove the other one. On the bottom, place a corrugated paper cap and then the "facing" apples, stems downward, fitting them firmly in place in rings. If to be "double faced," place another layer on this one. Then lower two basketfuls of fruit and upset them gently on the "facers." When the barrel is half full shake it gently to settle the fruit; when nearly full, shake again hard. Fill until the fruit is half an inch or an inch above the top, place and hold the head pieces in position, and give another thorough shake. Apply the press and squeeze down the head till it fits the chine, drive down the top hoops and nail securely. Put the label and address card on the opposite end.

APPLE, ROSE, *see Jambos.*

APRICOT, a round-headed tree with reddish-purple bark and broad nearly circular leaves. Both tree and fruit resemble those of peach and plum in general appearance. The fruit, which generally ripens earlier than either of these, is less fuzzy than the peach but more so than the plum. It has yellow, rather dry flesh and a large, smooth, flattened pit. In California apricots are cultivated commercially; east of the Rocky Mountains they are little grown except in home orchards. There are three groups of varieties, all of which probably came originally from China or Japan. The first or European group includes all the important varieties cultivated in America. Some of the best known are *Pringle*, *Newcastle*, *Royal Blenheim*, *Hemskirk*, and *Peach*, all of which are grown extensively in California. *Moorpark* is acknowledged to be the best in quality both in California and in eastern home orchards. Other varieties carried by eastern nurserymen include Alexis, Budd, Early Golden, Alexander, St. Ambroise, Harris, Montgamet, and Royal. The other two groups are little grown in America.

The apricot is an excellent home orchard fruit because it ripens earlier than most plums

and peaches, thus lengthening the stone fruit season. Its two chief enemies are spring frost, which often injures the blossoms, and the curculio, which attacks the fruit. Otherwise the tree is as easily managed as either peach or plum and thrives wherever they will grow, though it does best on stronger soil than suits the peach. A deep, dry, gravelly loam, such as suits the apple, is ideal. The trees are best set on a northern slope where the bloom will be retarded as much as possible and thus escape frosts. An elevated location near a lake, river, or even a pond from which winter winds will blow toward the orchard and delay blossoming, is desirable.

Tillage, pruning, protection from insects and diseases, and other cultural features are similar to those given under plum (p. 350). With proper handling and barring accidents, trees will bear every year; but under careless handling they have "off" years like apples and pears. Systematic thinning of the fruit insures annual crops. Fruit of the best quality is obtained by training the trees on trellises against walls (preferably facing north or west) though this requires much more pruning and attention.

APRICOT, ST. DOMINGO, *see Apple, Mammee.*

AQUACATE, *Mexican or South American name for Avocado, see below.*

ATTA, *see Annona.*

AVOCADO—mistakenly called alligator pear—is a very important tropical and half-tropical fruit. The tree, which naturally attains heights of 50 to 60 feet but which when budded and grown in the orchard is much smaller, is an excellent shade tree and may be planted for ornamental purposes as well as fruit production wherever the winter temperature does not go below 25 or 28 degrees. Certain varieties that for centuries have been grown in Mexico 6,000 feet to 7,000 feet above sea level, will also presumably succeed in sections of the United States where climatic conditions are similar; probably from Florida westward to California and in favored spots on the Atlantic Coast perhaps up to South Carolina. On the Pacific Coast, it is known to thrive as far north as Los Angeles. Of course,

FIG. 363. A cluster of Taft avocados

FIG. 364. Avocados are generally eaten with salt, pepper, and vinegar, alone or as a salad

it is necessary for such success that all growth be mature before cold weather sets in.

The fruits vary greatly in form, color, size, and quality. Some are almost globe-shaped, others pear-shaped, either long and slender or short and broad; some are light green, some dark, others maroon, crimson, or purple; some measure 1 to 4 inches in diameter and weigh only a few ounces, others attain a weight of 4 or 5 pounds. In some the skin is soft, yielding and as thin as an apple peel; in others it is coarse, woody and perhaps a fourth of an inch thick. Under the skin is a yellowish, buttery pulp, enclosing a seed that is sometimes as large as a hen's egg. Unlike most fruits, the avocado is rich in vegetable oils, containing sometimes 20 per cent or more. For this reason it is used more as a salad than a dessert fruit, being peeled, cut in half, freed of the seed and dressed with salt, pepper, and vinegar. In good varieties it has a delicate nutty flavor.

For the past 10 or 15 years the fruit has attracted considerable attention and commercial orchards have been established in the warmer sections of Florida and California. Before 1900 trees were propagated only by seed, but this gives such variable and unsatisfactory results that budding is now practically the only method followed.

The classes and types have not as yet been grouped and arranged. In California 2 sorts are grown; first, the Mexican, a small-fruited type, the oval or pear-shaped, thin-skinned "pears" weighing 4 to 8 ounces apiece; and second, the Guatemalan, a group bearing larger fruits with thick woody, often roughened skins, and with much better shipping qualities. In Florida, the commonest type is the West Indian of which the skin is sometimes as thick as that just described, but never as tough. Owing to their recent development, few if any varieties have become prominent. Lyon, Meserve, Taft, and Murietta in California and Trapp, Pollock, Rico, Chester, Blackman, and Family in Florida, are most worth mentioning. As in the case of the apple, varieties of avocado ripen at widely different times of the year, so in order to supply home demands and a local trade, a careful selection should be made to be sure of

FIG. 365. An avocado tree as received from the nursery.

a continuous yield over a long season. For **shipment** to distant markets varieties that ripen during the winter have proved most profitable because the fruit then meets but little competition. A good market size is one that weighs about a pound. Of course, oval or round fruits pack better than pear-shaped specimens. The yield of mature trees varies from a few dozen large fruits to 2,000 or 3,000 of the small Mexican sorts. An average is probably 200 to 300.

Orchard management. Budded trees are set 20 feet apart in Florida, 25 in California; seedlings require at least 30 feet. The best soil is a well-drained sandy loam, preferably on a slope, but heavy soils if well-drained will also grow good trees.

Planting is best done in early spring after danger from frost is past. The half dormant tree should be lifted carefully with a ball of earth around the roots and slightly pruned to balance top and root system. If the soil does not make balling possible, the trees while small should be grown in pots or boxes from which they can be set out without root injury.

Future cultivation is practically the same as that of orange (p. 337). Irrigation is necessary in dry sections especially until the trees become well established. Fertilizers containing 3 per cent nitrogen, 4 per cent phosphoric acid and 12 per cent potash have been suggested at the rate of 3 to 10 pounds to the tree, depending upon its age and the character of the soil. Fertilizers should be applied in several small doses rather than at one time. Leguminous cover crops are especially desirable.

In training, the trees should be encouraged to spread. Weak and sickly shoots must be cut out and wounds covered with grafting wax or paint to favor healing. Low heading is advised to prevent wind damage and to make picking easier. In the cooler sections trees should be protected by a winter mulch of palm leaves, corn stalks, etc. If irrigated, they should be well hardened off before winter by withholding water through late autumn.

The avocado has no serious enemies. Among those noticed in California are 2 or 3 scale insects while in Hawaii the avocado mealy bug is the most troublesome pest enemy. These may be controlled by contact sprays. In Florida a withering of the tips of the twigs, due to a fungus, may be controlled by bordeaux mixture.

For distant markets the fruits must be gathered before fully ripe, graded according to size, form, and color, and packed so they will not bruise. Of course, only good shipping varieties should be grown commercially. Light, wooden, well-ventilated crates holding only one layer of fruits each wrapped in stout paper are popular. For long shipments, especially in summer, it is also necessary to keep the fruit cold, a temperature of from 40 to 45 degrees being satisfactory. Anything lower than 40 tends to cause decay.

BANANA, a large perennial herb native to the tropics of the Eastern Hemisphere but cultivated in tropical and subtropical countries throughout the world. Like some of its close relatives, it yields a fibre used in manufacturing cord and fabrics, but its most important product is its fruit. This is extensively exported (especially from the West Indies, Central America and the northern countries of South America) to the United States, Canada, and less extensively to Europe. Among the score or more of species making up the banana genus or Musa as botanists call it, are 3 groups of edible-fruited plants: (1) the common banana which is usually eaten raw; (2) the plantain which is almost always eaten cooked; and (3) a dwarf plant with small edible fruits seldom seen outside the tropics. The two former grow from 10 to 25 or 30 feet tall. The stems are as soft as those of common garden rhubarb but are stiff enough to withstand even strong winds. The fruit cluster hangs with the fruits pointing upward. After the fruit has ripened the stem dies—like a raspberry cane—or becomes so weak that it is cut down. In a short time a new stem is developed, or sometimes several stems, as in the case of asparagus and peony, so the plant lives for many years producing from 1 to 3 or more fruit clusters annually.

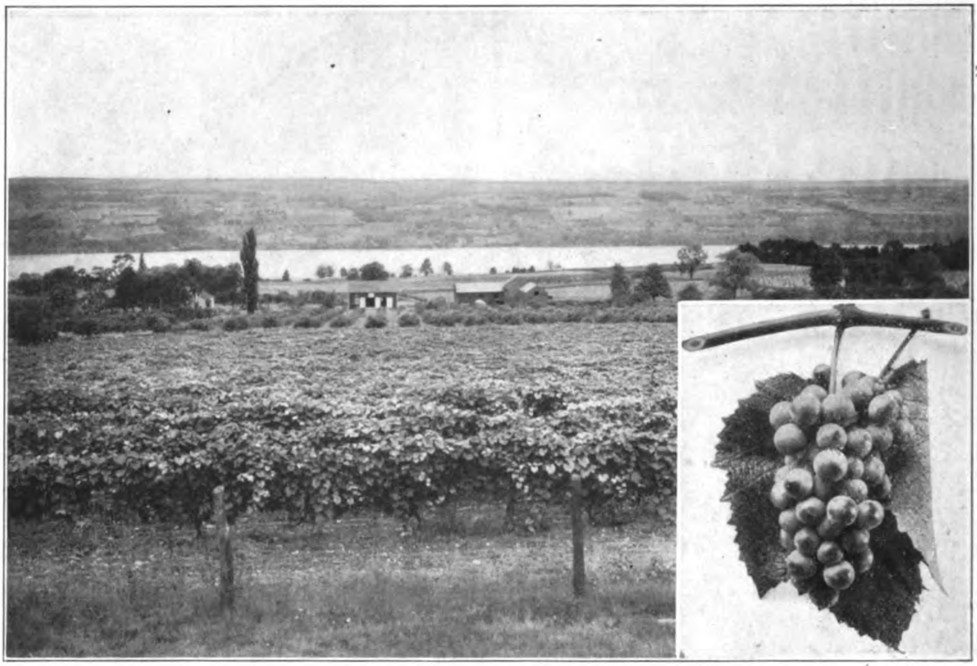
Because of the ease with which it can be cultivated, transported, handled, and kept in storage, and because of its widespread popularity, the banana has become one of the leading fruits consumed in North America. In the United States it is cultivated to some extent in the southern tip of Florida, the coastal part of southern Louisiana, and in scattered places westward to southern California. The leaves are known to have stood temperatures of 32 degrees. When merely the tops are killed by a temperature 4 or 5 degrees lower, new shoots appear from the crowns.

Bananas rarely produce seeds. They are, therefore, almost always propagated by

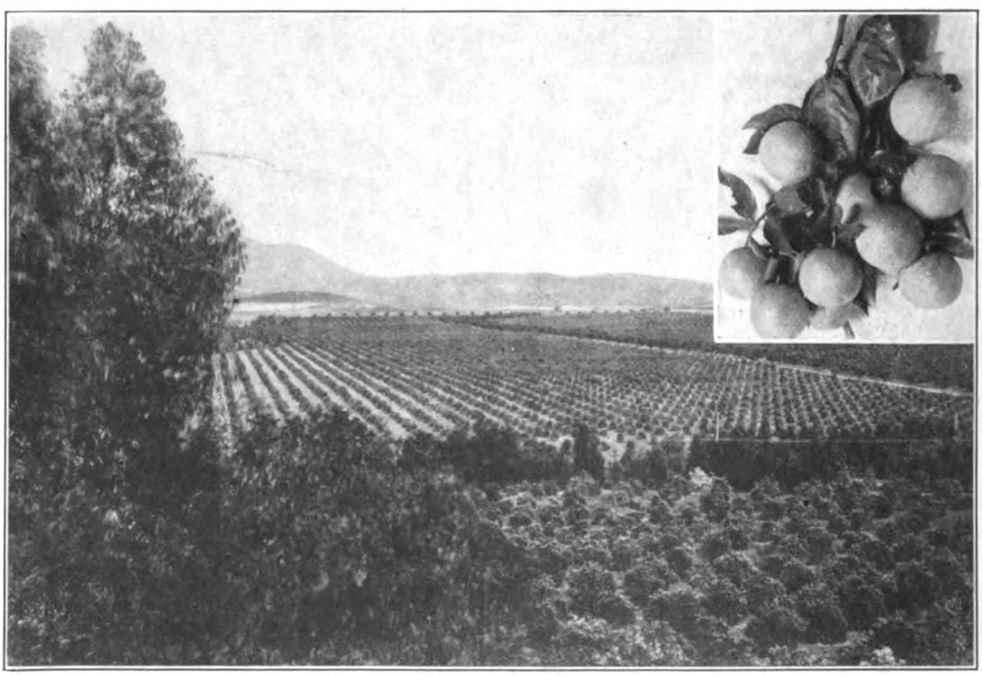
The apple is *the* fruit of America, attaining perfection, in some one of its many varieties, from the East to the West and from the North to the Middle-South

If the apple is king, surely the peach is queen among the royalty of tree fruits

THE SECRET OF SUCCESS WITH FRUITS IS THE PRODUCTION AND SALE OF QUALITY. THERE WILL NEVER BE AN OVERSUPPLY OF "THE BEST"



The history of the vine was old before the dawn of Christianity. But never were there so many excellent types and varieties for the grower to choose from, as there are to-day



As the American grape is of the North, so the orange is of the frostless South

THE FRUIT GROWER, OF ALL TYPES OF FARMER, IS A SPECIALIST, WHO MUST CHOOSE HIS LOCALITY, HIS VARIETIES AND HIS METHODS WITH INFINITE CARE

suckers. These are as easily separated from the parent plant as are those of the red raspberry. For quicker increase the entire rootstock may be cut up as blackberry rootstocks are cut to make new plants in nursery beds. After one or two leaves are formed, the little plants are transplanted. The banana does best in rich soil, on level lowlands and valleys where the water supply is ample.

BARBADOES GOOSEBERRY, a widely known tropical American species of cactus whose nearly smooth, lemon-colored, pear-or egg-shaped fruits about the size of olives are eaten to some extent. The plant is used largely as a stock upon which to graft other species of cacti. It is also known as blad apple and lemon vine.

BERGAMOT LIME, *see Limeberry.*

BILBERRY, *see Blueberry.*

BIWA, *see Loquat.*

BLACKBERRY. Any one of several American, European, or Asiatic shrubby perennial herbs with biennial, generally spiny, stems bearing black or sometimes whitish fruits. These consist of several to many tiny, cherry-like parts attached to each other and to a rather juicy whitish core (*receptacle*) which separates from the parent plant when ripe. The *Loganberry* is a hybrid between the blackberry and the raspberry. The Dewberry (p. 323) is a trailing blackberry.

The principal blackberry varieties are *Blower, Early Harvest, Briton, Eldorado, Minnewaski, McDonald, Erie, Snyder, Kittatinny, Wilson's Early, Ward, Mersereau, Rathbun, Taylor, Agawam, Wachusett Thornless, Early King, Iceberg,* (a so-called white), *Kenover, La Grange, Macataw, Texas Everbearing, Lawton,* and *Star of Wonder.* The dewberry group includes *Lucretia, Atlantic,* and *Austin's Improved.* The only important foreign addition to our American varieties is the *Himalaya,* of European or Asiatic origin.

Where grown. Some variety may be grown in nearly every part of the temperate zone, though many are not frost-proof and need winter protection. In hot climates, unless irrigated, or heavily mulched, the berries are few, small and poorly colored and flavored. Deep, clayey loam suits the plants best. Light soils are usually too hot and dry. General management is about the same as for the raspberry (p. 353). The blackberry is propagated by means of suckers and by root cuttings. The tips of young shoots should be pinched out when 4 to 5 feet high to induce growth of side branches. The plants need ample space, from 4 by 8 to 5 by 10 feet. A few fruits may ripen the second year after planting. Though the third summer may bring a profitable return, the plants do not bear abundantly until the fourth year. With proper care in fertilizing, cultivating, pruning, etc., a plantation should continue profitable for 8 or 10 years, though 6 to 8 is the usual commercial limit. Yields vary considerably

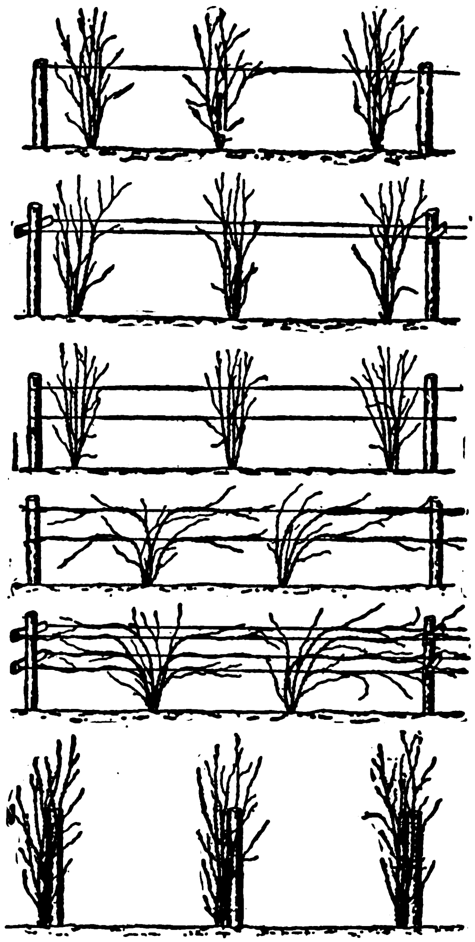


FIG. 366. Methods of training the blackberry. From above: (1) Upright type tied to single wire; (2) between two wires, side by side; (3) tied to two wires one above the other; (4) trailing type trained along two wires; (5) along four wires; (6) upright type tied to single post. (Farmers' Bulletin 643.)

with variety, soil, season, care, and other factors, from a fair average of 100 bushels an acre up to 200 and even 225 bushels. Prices also vary considerably, 6 to 7 cents a quart being usual, 10 to 15 frequent and 50 cents being sometimes obtained for extra choice fruit.

BLAD APPLE, *see Barbadoes Gooseberry.*

BLUEBERRY, HUCKLEBERRY, WHORTLEBERRY, BILBERRY are names loosely used for many species of shrubs mostly natives of the North Temperate zone especially in America. They are closely related to the cranberry and may be found growing wild in places similar to those in which that plant thrives. In the southern and central United

FIG. 367. Three-year-old improved blueberry plant. (This and Figs. 368 and 369, Bulletin 339, U. S. Dept. of Agr.).

States, the names blueberry and huckleberry are used freely for the same plant, but in New England, blueberry is used only for those kinds that have small seeds, while huckleberry or "crackerberry" is used for kinds with large crackly seeds. The true blueberry, whose fruits are light blue, sweet and high flavored, is far more valued in the markets and on the table. Indeed, the "crackerberries," especially in the South, injure the sale of the better berries if mixed with them.

Where and how grown. As several of the species bear abundant crops of large, delicious berries, it has often been asked why such attractive plants should have been almost kept out of cultivation. The truth is that attempts to cultivate them have so frequently failed that they have been allowed to grow wild until very recently. Through the work of Mr. F. V. Coville of the Department of Agriculture, the problem has now been solved. Mr. Coville has proved that success in blueberry culture depends upon two main factors: (1) the plants must have an acid soil and (2) they must have certain fungous plants, living on their roots, just as clover and alfalfa to be successful must bear "tubercles" or "nodules" on their roots. Furthermore, the soil must be well supplied with air. While the swamp blueberry grows in locations that are often flooded in winter and spring, its roots have plenty of air during the root-forming season; or if growing in places that are always wet, its shoots are raised well above the surface of the water. The plants do *not* thrive in soil that is always soggy. While the common low-bush blueberry fruits abundantly in sandy uplands, subject to drought, the swamp species grows best where the soil is naturally moist. In selecting a site for a plantation, the above conditions are of first importance but freedom from late spring frost must also be considered. The bottoms of valleys should be avoided because, while the blueberry plant itself is rarely injured by frost, the flowers and fruits often are. If this injury can be prevented by flooding without too much expense, low areas, ordinarily unfavorable, can sometimes be used.

Propagating. While plantations may be started with wild plants and by growing chance seedlings, neither give superior quality fruit. Until nurserymen can furnish plants propagated from superior stocks, the planter should transplant the best wild bushes he can find, choosing them when in fruit for size, color, flavor, and earliness of the berry, and vigor and productiveness of the bush. These may be propagated by both layering and by cuttings. A combination of these methods makes it possible to get several hundred new plants from one valuable old one, at one time.

"Stumping." The easiest way of propagating is by a special process of layering, called "stumping." In this, the stems are cut off at the surface in early spring. The stumps are covered to a depth of 2 to 3 inches, with a mixture of sand and sifted peat; a rough frame will keep the mixture in place. The sand must be kept moist during summer. New growth comes as scaly, erect or nearly erect root stocks which continue their development into leafy shoots on reaching the surface. In the fall, mulch the bed with leaves. In early spring, cut off the rooted shoots, remove the upper part except for 2 or 3 buds, and set the rooted cuttings in 3-inch pots in a soil mixture consisting of 2 parts, by bulk, of rotted upland peat and 1 part sand, putting the pots in a coldframe or cool greenhouse. Cover the frames with muslin to give plenty of light but no direct sunlight; and maintain a temperature of not to exceed 65 degrees F. for 2 or 3 months.

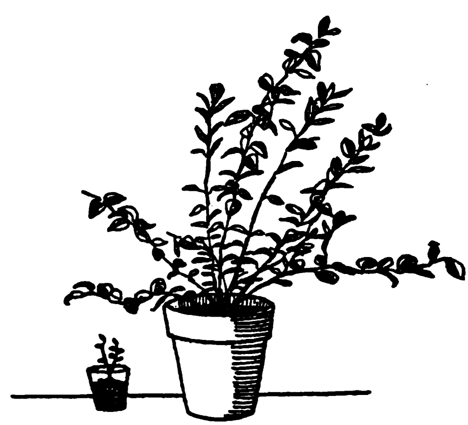


FIG. 368. Blueberries demand an acid soil. These two plants are the same age; that on the right is growing in an acid muck soil, that on the left in a rich sweet garden loam.

Yields. Blueberry plants do not come into commercial bearing in field plantations till 3 or 4 years old. Wild bushes live and produce to a great age but mature cultivated plantations are as yet rare. Near Elkhart, Indiana, is one about 2½ acres in extent. This was started in 1889 in a natural blueberry bog, first drained then set with unselected wild blueberry bushes. The average yield per acre from 1910 to 1915, including one year of almost total failure from frost, and another year of severe midsummer drought, was 1,741 quarts; the average price per quart, 14½ cents; average receipts per year, $243.44; average profits, $116. Annual expenses for weeding, cultivating, and irrigating were about $20 per acre. Picking was 5 cents per quart. These returns were from wild bushes; selected varieties would have made a better showing.

Only a beginning has been made in blueberry improvement. In a series of experiments, berries ⅞ inch in diameter have been produced in the greenhouse. The plant ought to prove of real value on many farms since it thrives best on soils so acid as to be considered worthless for ordinary agricultural purposes.

BRAZIL, PARA or CREAM NUT, or NIGGER-TOE, the nut of a South American tree said to be too tender for the United States, but known to be grown at Santa Barbara, California. Possibly it may also be grown in the warmest parts of Florida.

BREAD-FRUIT and JACA or JACK TREE, closely related East Indian trees useful for their timber, fibre, milky juice, and immature fruit which when baked resembles bread in texture and food value. Though introduced into the West Indies, they have not come into general cultivation there or in this country.

BUFFALOBERRY, a shrub 6 to 20 feet tall, native from Manitoba to the Rocky Mountains and southward to New Mexico and now cultivated in the prairie states for its ornamental silvery foliage and its berries (usually red) which make excellent sauce. Since male and female flowers are borne on different plants, it is necessary to have both in order to get fruit. Western nurserymen suggest 1 male to 4 female plants. The fruit, which varies in size, ripening season, and quality, can be easily dried for winter use, made into jelly and in some cases eaten raw, especially if slightly frosted. This plant offers splendid opportunity for improvement under cultivation and by selection of desirable types.

BULLOCK'S-HEART, *see Annona.*

BUTTERNUT, WHITE WALNUT. A large tree closely related to the Walnut (p. 357) but easily told from it because of its milder smelling leaves and long, sticky nuts, which are but slightly handled in commerce. The tree grows in moist situations from New Brunswick to South Carolina and westward to South Dakota and Arkansas, but is planted less than the Black Walnut. To get plants, bury nuts that have not been allowed to dry out, in the fall, in shallow boxes of sand, so that freezing may split them, that is, stratify them. In spring plant them where the trees are to stand so as to avoid transplanting. Scions from especially good trees may be grafted on the resulting seedlings in early spring, or buds may be inserted in midsummer by either the *flute* or *shield* method. Trees grown in the nursery row should be set out when one year or at most two years old.

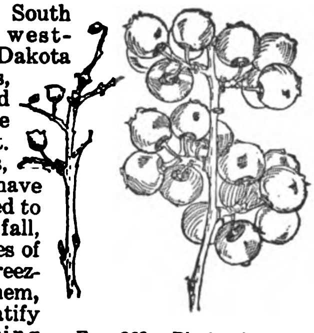


FIG. 369. Blueberries must be cross pollinated. The cluster at the right was; that at the left was not.

CALABASH, *see Granadilla.*

CALAMONDIN, *see Lime (fruit).*

CARAUNDA or CHRIST'S THORN, a small evergreen tree or large shrub sometimes 20 feet tall, with fragrant white flowers and reddish, cherry-sized, pleasantly flavored berries which are eaten raw when ripe, or pickled while green. As it is half hardy in central Florida and useful for both ornamental and hedge purposes, it should be in more common cultivation as a home fruit in the warmer parts of the United States. The Natal plum and the Amalungula or Mavitzgula are South African relatives, the latter with raspberry-flavored fruits often 1½ inches long and said to be unexcelled for jam making. These are also recommended for planting in the South.

CAROB, ALGAROBA, ST. JOHN'S BREAD, a large evergreen tree native to Palestine and Egypt. It resembles our locust tree in growth and fruit. The pulp around the seeds while sweet and edible is generally fed to live stock, especially pigs. Hence the belief that this is the "locusts and wild honey" upon which John the Baptist fed in the wilderness and the "husks" to which the Prodigal Son turned "when he had spent all." The tree thrives well in southern Florida and southern California where, like the Tamarind (p. 357), it should be more widely planted in home grounds and along roadsides.

CASHEW, a tropical American tree 20 to 40 feet high, cultivated in warm countries throughout the world, but in the United States only in sections absolutely free from frost. The white or yellow and red fruits which vary in size from that of a cherry to that of a peach are edible but acid in flavor.

FIG. 370. Sour cherry orchard about 15 years old. The trees are pruned to open centres and headed back to keep them low. (Farmers' Bulletin, 776.)

Their kidney or heart-shaped seeds are roasted and the kernels eaten like chestnuts.

CAVUL, *see Annona.*

CAYENNE, *see Cherry, Surinam.*

CERIMAN, a tropical climber with huge leaves dotted with holes, long aërial (air) roots and edible fruits which in flavor suggest a mixture of banana and pineapple. These are often 8 inches long, and somewhat resemble pine cones with 6-sided plates. The plant is popular as an ornamental in large northern hothouses.

CHERIMOLLA, *see Annona and*

CHERIMOYA or **CHERIMOYER,** a sub-tropical tree producing fruits of very variable size, shape, color, and general appearance. Some are heart-shaped and warty, others oval and dented, others smooth-skinned with "finger-marks," etc., but all are considered by many the finest of all sub-tropical fruits. The white pulp which separates readily from the seeds is slightly and pleasantly acid. Several varieties have been developed, the fruit of some weighing 15 pounds apiece, although the usual range is from 3 to 8 pounds.

The trees are generally from 15 to 20 feet tall and in the tropics can be grown only in the cooler climate of the uplands. In southern California they have been successfully grown among the foothills near the coast; and in southern Florida a hybrid form gives promise of success. So far as known there are no commercial orchards in the United States, the fruit having heretofore been consumed near where produced. Refrigerator cars and steamers should make shipment to northern markets possible.

CHERRY. Several species of trees and shrubs mostly native to the North Temperate Zone, a few of them being valued for their wood or fruit. The two leading species—the sweet and the sour—are natives of south-eastern Europe and southwestern Asia, but have escaped from cultivation and become wild in many parts of the world. Several other species are important as: (1) Mahaleb and Mazzard, both old-world species, used as stocks upon which the cultivated cherries are budded; (2) bird or pin cherry of eastern North America, and two dwarf species of the prairie states also for budding and (in the case of the last two) to some extent for fruit and ornamental planting; (3) two eastern Asiatic species, also similarly used. Altogether the group to which the cherry, plum, peach, and apricot belong contains upward of 120 species and constitutes one of the most important groups of related fruit-bearing plants of the world, especially of the temperate zones.

Types and varieties. Sweet cherries comprise three groups of several varieties each: (1) the BIGARREAUS, large, sweet, heart-shaped, light- or dark-colored varieties with firm flesh, *Yellow Spanish* and *Napoleon* (*or Royal Ann*) are typical of the light-colored varieties, and *Bing* and *Schmidt*, of the dark; (2) the HEARTS, similar to the above except that the flesh is soft. *Black Tartarian* is typical of the dark kinds, and *Governor Wood* of the light; (3) the DUKES, rather smaller, softer-fleshed and lighter-colored than the above and generally more tart but not so acid as the true sour cherries. *Reine Hortense* and *May Duke* are typical of this group. The Dukes are, doubtless, hybrids standing between the sweet and the sour cherries. The latter, tart varieties fall naturally into two groups: (1) the MORELLOS, rather small, very tart, dark-fleshed, and dark-juiced fruits, borne on smaller and more drooping trees than the sweet varieties, such as *Louis Philippe* and *English Morello*; and (2) the AMARELLES, lighter-colored, tart varieties with almost or quite colorless juice, borne on more upright trees than the Morellos. *Early Richmond* and *Montmorency* are leading varieties of this group. The varieties mentioned are the most prominent ones cultivated in America. If the beginner makes his first choice from among them he will probably make few mistakes, provided he gets stock true to name. Many cherry varieties, while desirable from the home standpoint, are too shy bearers, have too large a proportion of stone to flesh, ripen at the same time as other more profitable varieties, or are otherwise undesirable for business planting. For home use and to extend the season, a few of them might be added to the orchard for variety's sake.

Soils and planting. For sweet cherries, high, rather light, sandy, gravelly, or perhaps stony loams, especially of a shaly nature, give best results, whereas for the sour kinds heavier soils are better. It is customary to set sour cherries 16 to 20 feet apart and sweet ones 22 to 24, but these distances should be increased at least 25 per cent, in order to get desirably low-headed, spreading trees. Proper training and pruning while they are young

will insure this result provided the trees are not so close together that they are forced to grow upward.

Pruning. Cherry trees are usually headed at 2 or 3 feet; probably 15 inches or even less would be better. The limbs tend to rise so nearly straight that they rarely interfere with tillage tools. Generally 5 to 7 main limbs are started but often 1 or 2 of these are removed later. About the only pruning needed until the trees are in full bearing is the removal of branches that would interfere or that become injured. When they are 10 years old and older, more care is needed to keep the top down and the general form of the head broad and rather flat.

Bearing age. Cherries should begin to bear when 3 to 5 years set, the first to produce paying crops being usually the more productive of the sweet varieties at 5 or 6 years. Both sweet and sour varieties are usually profitable at 8 years of age. It is generally not a question of age but of size that determines how long cherry trees may yield profitable crops. Often trees exceed 100 years before they fail to produce fruit, but long before that, the cost of harvesting from their lofty branches is so great as to eat up the profits. For business purposes, cherry orchards are rarely allowed to reach more than 40 years of age.

Yields vary considerably, especially those of the two main classes. In the eastern United States, most productive sour kinds, when in full bearing, may yield 100 to 150 pounds to the tree per year, but 75 pounds is a good average; the sweet kinds in California probably average about 1,000 pounds, but yields of 2,000 pounds are not uncommon. At these rates, the profit from the sour kinds may range from $30 to $100 an acre and the sweet ones from $50 to $300.

Production. The extent of cherry growing in the United States is scarcely guessed mainly because the plantations are mostly in home orchards, the fruit being used locally or shipped to canneries. It is almost startling therefore to find the 1910 census showing 11,822,000 trees of bearing age and 5,622,000 young trees in United States orchards. The yield from the former is given as more than 4,126,000 bushels of fruit valued at $7,231,000. Thus the cherry is the fifth fruit in importance in America, following the apple, peach, plum, and pear. The figures show an increased production of more than 43 per cent in 10 years, the result mainly of improved transportation, refrigeration, better marketing facilities and increased demand for preserved and canned fruits. Better care of orchards and better methods of fighting enemies have also helped along this increase.

While cherries are grown more or less in every state of the union, their commercial production is limited to a few. The sour kinds thrive as far north as Newfoundland, and the sweet ones as far south as Florida.

FIG. 371. An old sweet cherry tree showing size attained when not pruned. (Farmers' Bulletin, 776.)

The value of the cherries produced by the leading states according to the 1910 census was: California $952,000; Pennsylvania $509,000; Ohio $657,000; Michigan $591,000; New York $545,000; Indiana $509,000. By 1917 these figures could have been increased probably 25 per cent because of increased planting. In the Pacific Coast states the sweet varieties are far the more important probably 90 per cent of the crop being of this type; in the eastern states, the reverse is probably true, mainly because the sweet kinds are more "finicky." The sour sorts are therefore more popular for home orchards where, only too often, they are neglected yet produce fruit to shame the owner. The trees suffer from insect and fungous enemies less than do sweet varieties.

Of the two groups, the sour kinds are adapted to a far wider range of conditions than are the sweet. Indeed they withstand cold, heat, dry, and moist air somewhat better than most of our other tree fruits.

Sweet varieties, in addition to being finicky as to soil requirements, lack ability to withstand both cold and heat especially at the period between blooming and fruiting, are more subject to insect enemies, and are attacked by all the fungous enemies common to peaches, plums, and other stone fruits. This array of objections should not prevent the planting of sweet kinds for home use, but should lead the would-be commercial planter to look into the local behavior of the varieties before investing heavily in a business planting of them. Other points which make cherries, both sweet and sour, popular for home use are their earliness in coming into bearing, their early ripening season (they are the earliest of the tree fruits) their annual bearing habit, their ease of handling and their general pro-

ductiveness. Besides all this the fruit is of the best for canning and preserving.

Propagating. Nurserymen use two species of stocks almost exclusively for budding both sweet and sour varieties—*Mazzard* and *Mahaleb*. In some cases where exceptional hardiness is sought, as in the cold northwestern states and adjacent Canada, seedlings of the bird cherry, *Bessey's* cherry or the *Russian* sour cherry are used. From the fruit growers' standpoint, the one best stock is the Mazzard because both sweet and sour varieties budded upon it make larger, thriftier, longer-lived and more productive trees. Such trees cost somewhat more than those budded upon the Mahaleb stock because they are harder to bud and grow, and slower to reach salable size, but fruit growers can well afford to pay for them 2 or 3 times the price of trees budded upon Mahaleb stock. The reason why nurserymen stick to the Mahaleb is that they have little or no trouble in raising the trees quickly to salable size. At 1 year, many trees budded on Mahaleb stocks may be sold, whereas at 2 years, many budded on Mazzard stocks are still undersized. Nevertheless, it is important to remember that a cherry orchard, being a permanent investment, should be started right—on Mazzard stocks except in very cold parts of the country when the other stocks mentioned may be given preference.

Fertilizing. In suitable soils, cherries rarely need commercial fertilizers; about all the needs of the tree will be supplied by the annual cover crop which, however, may be made better by fertilization. Should the trees not do well under such treatment, experiments may be tried with potash, phosphoric acid and nitrogen, preferably used separately as well as in combination to see which one is really needed.

Harvesting and marketing. Cherries must be picked without breaking the fruit spurs and thus ruining the chances for later crops, and without pulling the stems out of the fruit, else the wounds will "bleed" and the fruit soon spoil. Picking scissors are often used to prevent breaking the fruit spurs. Sweet varieties are generally gathered for market 2 or 3 days to a week before fully matured; sour ones when practically ripe.

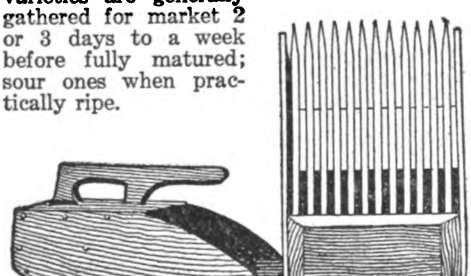


FIG. 372. Side and bottom views of a cranberry picker handled like a dust pan. (This and Figs. 373, 374, and 375, from Farmers' Bulletin 176.)

For distant shipment cherries are generally packed in boxes or baskets of small size; for the cannery and local markets, in trays or baskets holding a peck or two each.

CHERRY, SURINAM, CAYENNE, or PITANGA. A Brazilian shrub 20 feet tall, cultivated for its ribbed, cherry-like berries which ripen in May or June. It is hardy in southern Florida and southern California where it is somewhat cultivated for jelly-making. As a house plant it is very attractive when in fruit.

CHESTNUT. Comprises about 10 species of trees, some of which are important because of their edible nuts and their coarse-grained wood that makes excellent fence posts, railway ties and durable lumber (Chapter 29). They are also highly valued for ornamental planting.

Types and varieties. In the United States, 3 of the species have become prominent because of their nuts: (1) the EUROPEAN is a tree often 75 feet tall, bears very large burs, and nuts of extremely variable quality—from astringent and insipid to rather sweet. It is also known as FRENCH, ITALIAN, and SPANISH, and has given rise to several varieties of which the best known are *Styer*, *Anderson*, *Scott*, *Bartram*, *Ridgley*, *Comball*, *Quercy*, *Chalon*, *Numbo*, *Corson*, *Lyon*, *Nouzillard*, *Darlington*, *Moncur*, *Marron*, and *Paragon*, the last also known as *Sober* and *Great American*.

(2) THE JAPANESE, a shrubby tree sometimes 30 feet tall, bears small burs but large glossy nuts, often 5 to 7 in a bur. Though many of its varieties are inferior in quality to cultivated European chestnuts, they are good when cooked. Among the best known kinds are *Superb*, *Alpha*, *Success*, *Beta*, *Reliance*, *Biddle*, *Coe*, *Parry*, *Black*, *McFarland*, *Boone*, *Martin*, *Felton*, *Mammoth*, *Giant*, *Killen*, *Kerr*, *Hale*, *Kent*, and *Prolific*.

(3) THE AMERICAN, a tree often 100 feet tall and 4 or 5 feet (sometimes more than 10 feet)—in diameter, with burs rather smaller than those of the European group, and small nuts of high quality—the best of all chestnuts. A few varieties have been selected for grafting but have not been fully tested. Among the named varieties the following are perhaps best known: *Hathaway*, *Griffin*, *Ketcham*, *Dulaney*, *Watson*, *Nursell*, *Otto*, and *Rochester*. Some of the objections to American varieties are their frequent sterility when planted singly or in blocks of only one variety, and their susceptibility to leaf diseases and attacks by weevils. The European varieties seem to be somewhat less susceptible but their lower quality has kept them from gaining rapidly in popularity though they have been grown in the United States for more than 100 years. Some of the Japanese varieties that have originated in this country, and some of the imported ones are equal to the European having the advantages of being earlier in

bearing, more productive, larger, and freer from insects and diseases. Besides these 3 principal species, are several dwarfer ones popularly called Chinkapins or Chinquapins, the best known of which is a native American shrub usually only 4 to 5 feet tall but sometimes growing to 50 feet. Two varieties—*Rush* and *Fuller*—have been offered for sale by nurserymen.

Where grown. Native American chestnuts are found growing from Maine to Michigan and southward to Alabama and Mississippi. Judging from this, cultivation should be successful throughout a somewhat wider area where climatic conditions are similar. In nature, the trees are found on sandy, gravelly, and rocky, well-drained, light soils; they rarely succeed on rich or heavy loams or limestone soil unless exceptionally dry and deep.

Propagating. The easiest way to propagate the chestnut is by seeds sown in the fall before the nuts become dry. They must be protected from mice and squirrels. Another good way is to place alternate layers of nuts and sand in boxes which are then buried 1 or 2 feet deep in a sandy or gravelly knoll until early spring, when they are dug up and the seeds sown about 3 inches deep in warm, light soil. This practice is called "stratifying." The seeds may be 4 to 6 inches asunder in rows 2 or 3 feet apart. During the summer, ordinary cultivation only is necessary.

Planting. In the fall or the following spring, the seedlings may be set in a block 2 or 3 feet apart each way and allowed to remain thus for 2 or 3 years before being transplanted to permanent quarters. Here they may stand 4 feet apart at first so as to develop erect, branchless trunks. In 5 to 10 years each alternate tree may be removed for poles or posts. In another 5 or 10 years, a second thinning may be made and so on until the trees stand perhaps 64 feet apart. Nuts may be expected in from 5 to 10 years after planting in the field.

Grafting. In localities where chestnuts are growing wild, a favorite way to develop a plantation of named varieties is by grafting. The preferred way is to cut down the large trees so as to produce sprouts from the stumps. Any kind of chestnut will do for stock; so will the chestnut oak, though the resulting tree may not be fully satisfactory. Splice grafting is a simple way of handling one-year seedling roots, the grafts being handled like those of apple. Cleft grafting at the crown is the most popular method when the sprouts are 2 or 3 years old. Splice and veneer grafting are also used to some extent on sprouts of these ages. Top-working of old trees is not fully satisfactory. In all cases, the scions must be kept dormant (best buried in a cold place) until the leaves begin to appear.

CHINKAPIN or CHINQUAPIN, an American species of chestnut usually only 4 or 5 feet tall but sometimes reaching 40 or 50 feet and bearing cylindrical nuts rarely exceeding ¾ of an inch in length. (See above.)

CHRIST'S THORN, *see Carunda.*

CITRON, a variety of watermelon (see Chapter 28); also a large citrus fruit, resembling the lemon as to form and habits of tree. The fruit is as large as a grapefruit or large orange with a very thick rind and a small amount of tart pulp. The rind when "candied" is used in cooking and candy making. Nearly all that used in America is imported, mainly from Mediterranean countries, but since 1894 when the Federal Department of Agriculture imported plants of the Corsican citron, the tree has been grown on a small scale in California. Its management is the same as that of the lemon (p. 332).

COCOANUT, a large American, West Indian and South American palm tree grown near the sea coasts of all tropical countries, of which the large, hard-shelled, meaty fruit is eaten both raw and cooked, and the oil, stems, leaves, fibre, and husks are used in many ways. While it is grown somewhat beyond the limits of the tropics, it thrives only where the climate is uniform with an average annual temperature of not less than 72 degrees and no frosts. It can be grown in the United States only in the warmest sections of Florida and California and success is not certain even there. It does not, as formerly believed, require the near presence of the ocean, but a plentiful supply of ground water is essential, an annual well-distributed rainfall of at least 40 inches being necessary. In such favorable locations trees grow on poor, sandy soils and will withstand droughts, severe winds, and even sea water about their roots for brief periods.

Cocoanuts are raised only from seeds which should be selected from choice trees, and started in nursery beds, the seedlings being transplanted when conveniently large. Crops that do not demand too much water are usually grown between the orchard rows for 2 or 3 years. By the fourth year the trees shade the ground which then frequently is pastured with cattle. Well-cared-for trees

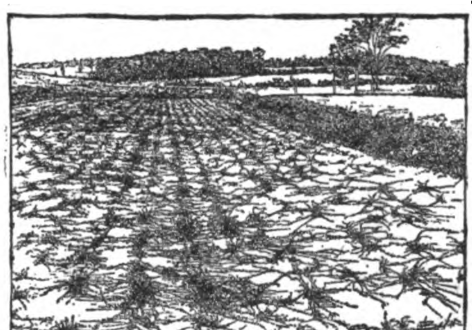


FIG. 373. One-year-old cranberry bog showing how the plants, set in rows, soon spread and cover the ground

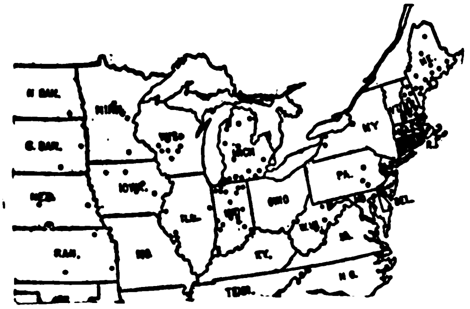


FIG. 374. The black dots show where cranberries are grown commercially, the small circles where they grow wild.

may begin to bear at 5 years, but 7 or 8 is the usual age, and a neglected tree may not yield until 15 years old or more. It is said that a mature tree, which may be 100 feet high, will bear a ripe cocoanut for every day in the year.

CORESOL, *see Annona.*

COWBERRY or FOXBERRY, a low-growing shrub native of the colder parts of the North Temperate Zone. Its acid, rather bitter, dark red berries, the size of currants, are largely used in the North for tarts, jams, and jellies. Except in a small way, it is not in cultivation but is worth attention in cold regions where other fruits fail.

CRANBERRY. Two native North American trailing fruit plants, one of which, the large cranberry, is cultivated on thousands of acres mainly in Massachusetts, New Jersey, Wisconsin, and Long Island, New York. Unlike most cultivated plants, the cranberry thrives in acid, swampy land in cool, Northern sections. Under wild conditions, the berries, which ripen in the fall, often hang on the vines till the following summer. The low-bush cranberry or wolf-berry is not cultivated, but large quantities reach the Boston market from Nova Scotia. Cranberry growing is scarcely more than 100 years old. Writings show that in 1841 yields of 6,400 or more quarts to the acre were counted upon; nowadays, with improved varieties, yields of 20,000 quarts to the acre are sometimes secured. According to the census of 1909 cranberries are grown in 30 states. In 9 of these the yield reported was less than 5,000 quarts; in 7 it was more than 100,000 quarts. Massachusetts reported 22,714,000 quarts; New Jersey, 12,072,000, Wisconsin 2,549,000, and New York 327,000.

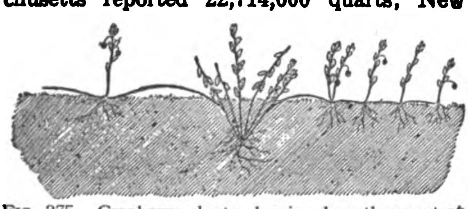


FIG. 375. Cranberry plants showing how they root at the joints and how the berries are borne

Varieties. All the cultivated varieties are chance seedlings found in natural or cultivated bogs. They vary greatly in size, shape, color, season, productivity and adaptability to soil and situation. Among the most popular are the *Howes* and the *Early Black*, the former ready to gather in Massachusetts in early September, the latter not until mid-October.

Where grown. To insure success in cranberry growing, it must be possible to drain the bog to a depth of one foot during the growing season. However, since the soil must not become dry, it is just as essential that enough water be available to flood the whole field. This is also done to protect the plants from frost and insect damage. It is highly desirable that the area be fairly level so it may be flooded uniformly. Lastly, the bog should not be too subject to frost injury. Indications of suitable soil are brownish water in the pools and streams, and blueberries, leatherleaf, swamp cedar, and swamp maple growing

FIG. 376. Cranberry picking scene

naturally in the swamp. If the soil is of a black, peaty formation so much the better, especially if this is deep and overlies sand and hardpan. Unless the area can be readily drained and as readily flooded, failure is almost certain.

The water supply. After the area is cleared, the first requisite is a dam. Its foundation must extend below the layer of peat to the underlying sand, and the sand embankment must be high enough to provide at least a foot of water above the plants during flooding time. This may call for embankments 6 feet or more in height. To prevent soil washing, the faces of the embankment must be sodded. To provide for rapid draining of water, and also quickly flooding, side ditches must be built, and to provide for quick flooding, a reservoir above the bog is an important safeguard. Accidental overflow also must be guarded against, else the crop might be destroyed if flooded during bloom. In practice, the water is turned on

after the vines have become red (usually in December), and kept on until late April or early May. Thus the date when growth starts may be controlled. Should frost threaten, the bog may be reflooded. It is customary to flood about June 1 for 24 or 48 hours, to kill insects. To irrigate or dry off the soil during the summer, it is only necessary to raise or lower the water in the ditches.

Planting and care. After the land has been cleared and leveled, cuttings 8 to 10 inches long are pushed obliquely into the soil 12 to 15 inches apart leaving only 2 to 4 inches of the top showing. Runners are produced and in a short time the bog becomes a mass of vines some of which are 6 or more feet long and rooted in many places. From the runners, upright stems 6 to 12 inches long are produced. These are the fruit-bearing parts. A crop may be expected in 3 to 5 years. In view of the nature of the plant, cultivation after the first year is impossible; hand weeding is about all that can be done. Dressings of sand —half an inch to an inch deep—are given every 2 or 3 years in sections where sand-surfaced beds are popular. Commercial fertilizers have been used with apparently favorable results, and spraying with bordeaux mixture is done to prevent "scald," a fungous malady.

Harvesting and marketing. Cranberries are picked by hand or with a "scoop" which is a shallow box shaped somewhat like a dust pan with a comb in front. To make scooping easier, the vines may be pruned with a rake in which the teeth are knives set about 6 inches apart.

Part of the berries gathered may be packed in the field and marketed at once, but the bulk of the crop is stored in well-ventilated quarters for perhaps several months. It is then cleaned by means of special machines, and marketed mostly in crates and 100-quart barrels. Best results are secured when the berries are sold "in the chaff" (uncleaned) in crates because they keep better than when cleaned before shipment, and dealers are better pleased. A considerable business in evaporated cranberries is developing, mainly because the berries lose practically none of their flavor under such treatment.

No one should undertake cranberry growing until after reading all available literature upon the subject and, if possible, visiting several successful bogs. The United States Department of Agriculture and the experiment stations of New Jersey, Wisconsin, and Massachusetts have each published bulletins on cranberry culture, insects, etc., and in addition the reports of the American, the Cape Cod, and the Wisconsin Cranberry Growers' Associations contain much valuable information.

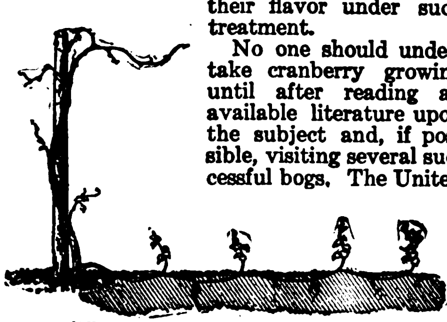


FIG. 377. Vine-layering, a method of propagation adapted to most bush fruits with flexible stems

CREAM NUT, *see Brazilnut.*

CURRANT. The name currant is a mispronunciation of "Corinth" noted in Bible history and formerly given to a small-fruited grape grown mostly around the Mediterranean Sea and which is the source of the dried currants of commerce. Later the name was applied to our cultivated bush fruit which is native to the colder parts of the Temperate Zone, but which was not cultivated until about 1550. The currants grown in America have mostly been derived from two European species, a red- and a black-fruited kind, the former also giving rise to several white-fruited varieties. There are also several varieties which have been developed from 3 American species, but these are of small consequence as market fruits.

Varieties. Among the best known are: *red, Pomona; Moore's, Ruby, Cherry, Diploma, Jefferson County, Perfection, Versailles, Prince Albert, Red Dutch, Fay, Comet, Wilder, Franco-German, Victoria, Cumberland Red, Long-Bunched Holland, Red Grape,* and *Red Cross; black, Saunders, Black Victoria, Collins Prolific, Boskoop Giant, Buddenborg, Eclipse, Magnus, Climax, Clipper, Success,* and *Eagle; white, Large White, White Grape, White Cherry,* and *White Dutch.* The only important variety of an American currant is the *Crandall.* It is not likely to be commercially popular because its fruit is inferior to that of the other sorts and ripens too unevenly.

Where grown. Since all the species are natives of cold, even very cold, climates, their varieties may be planted with confidence as far north as any other fruit. They do not succeed in the South except at high altitudes. A rich, deep, strong, well-drained but moist soil suits them best. As the plants are shallow-rooted, they suffer if set in shallow soil, especially if dry and hot. If there is danger of soil dryness, the plants may be set on a northern slope or in the partial shade of fruit trees and grape vines.

Propagation. Currants are easily propagated by layers and cuttings (p. 329). After growing one or two years in the nursery, the plants may be set in the field, preferably in autumn as soon as the leaves have fallen. Thus they become established before winter and start off without check the following spring. This is important because the plants leaf out very early, often while snow is still on the ground. If set in spring they are likely to suffer through having already started their root and perhaps also their leaf development.

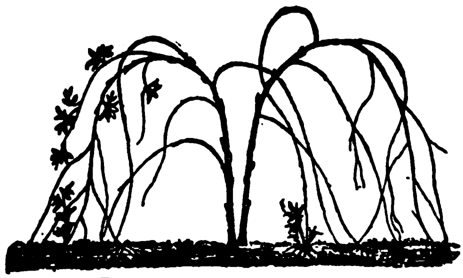


FIG. 378. Tip-layering, a popular method for propagating blackberries and some raspberries

How grown. As the plants grow large under favorable conditions, they should be given liberal space which they will pay for in larger, more abundant fruits. Many plantations are made 4 by 4 feet; some 5 by 5; but the best 6 by 6 or even more. When strong 1-year-old plants can be obtained, they are to be preferred to older ones, but well-grown 2-year plants are better than younger, poorly-rooted ones. Currants should be planted deep with part of the stem covered and the roots extending straight down to the bottom of the holes so as to be able to withstand dry weather better than if spread out nearer the surface.

Cultivation. Clean cultivation from the start and each season until midsummer when a cover crop may be planted is the keynote of success. Crimson clover is one of the best cover crops in this connection. The first year or two, cultivation should be deep so as to prevent root formation near the surface. After the second or third year when the lower roots have become developed, the formation of surface roots may be encouraged by shallow cultivation. Plants so trained in root formation should withstand even severe droughts, yet bear well.

Fertilizing. No manure will be needed on fertile soils after the first spring until the plants begin to bear, which they should do when 2 years set. Then liberal dressings of manure should be given. Perhaps no other fruit will stand such liberal feeding with nitrogenous fertilizers. When only light dressings can be made, 200 to 300 pounds of hardwood ashes or muriate of potash will be helpful.

Pruning. Black currants bear most of their fruit on last year's wood, and should be forced to produce plenty of young shoots each year. Red and white varieties develop fruit spurs or twigs on canes 2 or more years old. Hence they should include several canes respectively 1, 2, 3, and 4 years old, so as to keep up a succession of strong bearing wood. Canes begin to fail after 4 years, so it is well to cut out the 4-year old wood as soon as the crop has been gathered. Each year 2 to 4 of the best shoots that spring from the stool should be encouraged by cutting out all the young inferior stuff. Thus a well-managed white or red currant bush should have 6 to 12 sturdy canes all the time after the plants are 3 years old. The old canes should be burned as soon as cut out so as to destroy borers and other enemies that may be in or on them. Except to keep the bushes in good form, no other pruning is necessary. Plants properly handled should continue productive until 10 or perhaps 15 years old. Commercial growers generally calculate on 6 or 8 good crops before pulling up and burning a plantation, but 10 are not uncommon.

Yields. As currants are rarely affected by frost, they are among the most regular annual bearing fruit crops; and as they are naturally productive, they should yield heavily under good treatment. Yields of 3,000 to 5,000 quarts to the acre are common and of 10,000 quarts not extraordinary. As an average for 4 years, at the Central Experimental Farm at Ottawa, Canada, the Red Dutch variety, planted 5 by 6 feet apart, yielded 5,856 quarts to the acre. Individual bushes averaged more than 70 pounds of fruit—more than a bushel and a half. At this rate and at 40 pounds to the bushel, an acre of such plants would have yielded more than 14,300 quarts. Such possible yields should act as a spur to growers to make the most of their plants. The yield of black currants is usually smaller than that of red varieties. *Saunders* has yielded more than 5,200 quarts to the acre; *Kerny* nearly as much, with individual plants set 5 by 6 feet averaging more than 60 pounds to the plant—equivalent to almost 12,000 quarts to the acre.

As few people relish such acid fruits in the raw state, currants are grown in America mainly for making preserves, jams and jelly. While varieties differ as to acidity, these differences are too slight to warrant calling any of them "sweet."

CUSTARD-APPLE, see *Annona*.

CUSTARD APPLE, see *Pawpaw*.

CYPHOMANDRA, or tree tomato, is a South American shrub-like tree sometimes cultivated in warm countries and greenhouses for its edible, egg-shaped, tomato-like fruit.

DATE. An African or Arabian palm tree widely cultivated for its fruit in the Old World

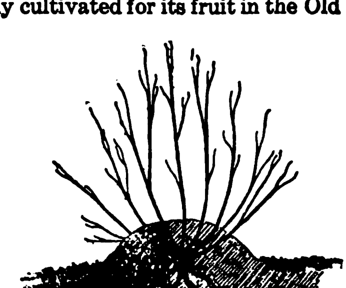


FIG. 379. Mound-layering, the preferred method for propagating currants and gooseberries. After the branches root, the soil is removed and the new plants are cut away.

where for thousands of years it has supplied a valued article of food. Trees have been growing in South and Central America and Mexico for several centuries, and during the last 25 years plantings have been made in the southwestern parts of the United States, and are now giving promise of good returns. Trees grow to be 100 feet or more in height and may bear fruit for 100 or 200 years.

The male (pistillate) and female (staminate) fruit-producing flowers are borne on different trees, so it is necessary to plant the two kinds near together in order that fertilization shall result. One male to 6 or 8 female trees will do. The Arabs, the original date growers, tie clusters of mature male flowers among those of the ripe female blossoms to insure the formation of fruits. In order to avoid growing too many male trees and to offset the tendency to variation in seedlings, propagation is generally accomplished by means of suckers, except when new varieties are sought.

Being naturally a desert plant, the date thrives in this country only in Lower California and the Salt River Valley of Arizona. Although the outlook for the cultivation of this fruit in a few, hot, dry, irrigated sections is bright, any one thinking of growing the date should start gradually and carefully after obtaining all possible information and assistance from the agencies just mentioned.

DEWBERRY. A trailing or half-climbing American shrubby perennial which bears fruit resembling blackberries, but usually several weeks earlier. Botanists consider dewberries as merely trailing varieties of blackberries. Fruit growers separate the two, first because of their habits of growth; and second, because dewberries root at the tips of their canes and from new plants in the same way as black raspberries. The dewberry dates back as a cultivated plant only to about 1860, and as a commercial crop to the late 'nineties. It is difficult to manage and the most uncertain of the bush fruits as to bearing habits because it needs cross pollination, the most whimsical as to soils, and the most tender of all the bramble fruits as a class. Nevertheless, the number of its varieties and the acreage under cultivation increase annually, mainly because the fruit fills a niche not filled by any other fruit of its season. When properly grown in favorable soil and climate, it yields bigger, better, more attractive fruits than any of the blackberries.

Varieties. A dewberry plantation should consist of at least 2 varieties to insure cross pollination, otherwise there will be little but nubbins. Of the 30 or more varieties now listed, *Lucretia, Premo, Austin,* and *Bartel* are the best with the Lucretia the most widely grown, and most widely adapted to various soils and environments.

How grown. While cultivation of dewberries is practically the same as that of blackberries, the former demand much more care in

FIG. 380. Dewberry field showing each two plants in a row trained to one stake. (Farmers' Bulletin 728).

training and generally better protection in winter. Generally the vines are trained like grapes on an ordinary 2- or 3-wire trellis, one above the other; or on a T-shaped trellis with a wire at each end of the cross piece and a third stapled to the post about a foot lower. Staking is popular, but is less satisfactory. The ends sought in training are to keep the fruit out of the dirt, to regulate the bearing wood and to keep the canes away from the tillage tools. In commercial plantations, the plants are usually set about 4 feet apart in rows 7 feet apart. In pruning, the tips of the young canes are pinched when they get 4 or 5 feet long. This helps to prevent them from sprawling. The laterals or secondary shoots that develop soon after this pinching are also pinched when 15 to 24 inches long. As only 4 to 6 canes are allowed to develop from each stool, the trellises should not become choked with vines when such pruning is practised, and when the canes that have fruited are cut out as soon as harvest is over.

In cold climates, the vines must be laid on the ground in late fall and covered with strawy litter to protect them from frost.

EGG-FRUIT, *see Marmalade tree.*

FARKLEBERRY, SPARKLEBERRY. A small, shrubby tree found in sandy soil on river banks from North Carolina to Illinois and the Gulf of Mexico. Its small blueberry-like, somewhat astringent berries are sometimes used for preserves.

FIG. A small tree or large shrub sometimes 30 feet high and usually wide-spreading, native to Palestine, Egypt, and other warm countries in the Old World, whence it has been distributed to tropical and subtropical countries in the Western Hemisphere. In America, some of the varieties will stand 10 to 20 degrees of frost, and bear fruit as far north as Newburgh, New York, and Detroit, Mich., without protection. They do better, however, with protection of soil, boards, or straw. While they have fruited on Long Island and the coastal section of New Jersey, trees do better from Virginia to Texas in a strip of territory only a few miles wide in the north but 50 to 100 or more miles wide where it

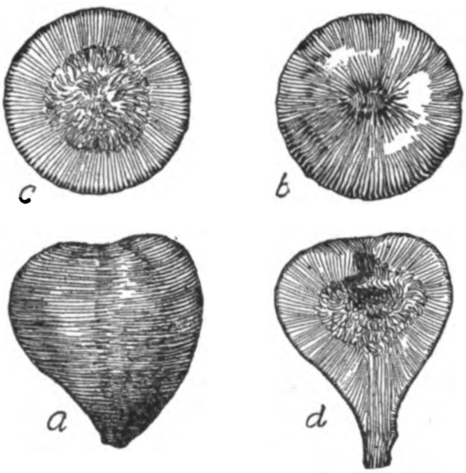


FIG. 381. A ripe Smyrna fig whole, seen from the side *a* and the bottom *b*; and cut in half across *c*, and up and down *d*. Note the central cavity nearly filled with blossoms which later produce the seeds. (Ariz. Bulletin 77.)

bends around the Gulf of Mexico. In California, where it has been cultivated for more than 200 years, the fig is well established where fruit of any kind is grown provided the temperature does not fall below 18 degrees. In the southeastern and Gulf states, the fig has been a dooryard fruit since the days of the earliest settlers. But not until early in this century did it become commercially important. Soils best suited to the fig are heavy loams which naturally hold moisture well. It fails in the South on light soils because of root knot or nematode worms.

Types. There are four important groups of figs: (1) the Capri or common fig, inedible but important because it supports the fig-wasp or Blastophaga, an insect necessary to the formation of fruit on the Smyrna fig. (2) the Smyrna including several varieties important because of their high quality and the ease with which they are dried for market. (3) The self-fertilizing figs common in the South. (4) A group of varieties which will produce 1 crop without fertilization, but must have the blossoms of later crops fertilized. Figs bear their fruit on young wood, often 2 and sometimes 3 times in the year. The fruits are hollow, pear-shaped affairs with the seeds inside which condition has given rise to the belief that the trees produce fruits without flowering. The United States Census of 1910 says that fig growing is more widely distributed than citrus growing. There were 882,000 bearing trees in 1909, but a larger number not of bearing age. Production in 1909 was 35,060,000 pounds valued at $804,000, California producing nearly two thirds of the crop. As about 600,000 pounds of dried figs is the output of Smyrna in good seasons, the United States appears to stand a good chance of developing this industry.

Varieties. Because the Smyrna figs require pollination and because the climate of the southeastern states is not favorable to them, planters there should select common kinds of which the following are most successful: *Black Ischia*, hardy, strong-growing, late, medium to large, bluish-black, creamy-fleshed, of good quality; *Brunswick*, midseason to late, tough-skinned, dark brown, of fair quality, recommended for market because of its large size; *Celeste*, small, violet-colored, early, recommended because of its hardiness and high quality; *Turkey* or *Brown Turkey*, hardy, prolific, mid- to late- season, coppery colored, with whitish flesh of excellent quality; *Magnolia*, vigorous, prolific, large amber-fruited, excellent for canning; *Lemon*, early, medium to large, yellowish, green-fruited, of medium quality; *White Ischia*, late, very prolific, greenish-yellow, red-fleshed, of high quality. *White Magnolia* is the leading variety southward from Magnolia, Texas, but elsewhere its fruit splits and turns sour in the rainy weather that usually comes at ripening time. Of the 7 varieties mentioned, *Turkey* and *Celeste* are best for the colder parts of the fig belt.

Propagating and planting. Figs are readily grown from cuttings of the previous season's growth, cut at the joint and treated like those of the grape (p. 329). They may also be propagated by ring budding. In the South, the plants are set in the orchard at 1 or 2 years old, 10 by 15 or 12 by 20 feet apart. In California they are generally spaced 40 or even 50 feet apart, fillers being grown while the fig trees are small. In the warm regions, January and February are the usual months for transplanting; in colder sections, March or April. It is imperative that the roots be kept moist. The tops are generally cut back severely to make a bushy form of 3 to 5 trunks. Only the removal of suckers and light annual pruning for form are usually necessary thereafter.

Cultivation is given annually till the trees shade the ground. Deep tillage must be avoided because the fig is very shallow-rooted, but surface tillage is necessary for best results. It should start just before growth begins and continue till midsummer, when cow-

FIG. 382. Fig trees showing methods of pruning: *a* single stem; *b* vase or bush form. (Tex. Bulletin 208)

peas or beggarweed should be sown as a cover crop. Liberal dressings of stable manure are excellent.

Harvesting and marketing. The first fruits ripen often during the third, and sometimes during the second year after planting. Much of the fruit is marketed fresh, but the great bulk is preserved in canneries to meet the steadily increasing demand. In gathering, it is important to cut only the well-colored but firm fruits in the early morning while it is still cool, and to pack them without bruising in strawberry boxes and crates for shipment by express. By this means, they may be shipped 100 miles without trouble but except under refrigeration, they cannot be shipped much farther. They rarely appear in good condition in northern markets.

FIG, INDIAN, *see Prickly Pear.*

FILBERT, *see Hazel.*

FOXBERRY, *see Cowberry.*

GINEP, *see Lime, Spanish.*

GOLDEN APPLE, *see Jew Plum.*

GOOSEBERRY. A bush of which the fruits are usually gathered before fully ripe and made into jam. It is less widely cultivated in the United States than in Canada, and less there than in Great Britain or, in fact, all of northern Europe. Since its introduction into cultivation from the wilds of northern Europe—probably in the sixteenth century—it has been wonderfully improved; whereas berries used to weigh less than a quarter of an ounce, specimens weighing 2 ounces and with greatly improved flavor have recently been grown. In the United States and Canada, the fruits are usually smaller than those of European varieties, partly because the climate is less favorable to their best development and partly because they have been derived from separate American species.

Varieties. The first to be introduced in 1847, was the *Houghton* which originated in Massachusetts. The *Downing* announced in 1853, was the second; yet so slowly has interest in the gooseberry awakened that this variety is still more widely planted in America than any other. Among better American or hybrid varieties are *Pearl*, *Josselyn* (*Red Jacket*) and *Poorman*. Among the European varieties most likely to succeed in America are *Whitesmith*, *Industry*, *Eagle*, *Companion*, *Queen of Trumps*, *Glenton Green*, and *Snowball*.

Where grown. Where the summer air is humid and the ground heavy and cool, and the summer supply of soil moisture constant, the chances of success with gooseberries are greater than where either is dry. In America a thickly planted home garden, therefore, is usually a far better place than the open field. Well-drained, rich, heavy loams suit them best. The plants are gross feeders and will, therefore, stand heavy dressings of manure. Since gooseberries, like currants, grow wild as far north as the Arctic Circle, they should become one of the leading fruits in cold climates and at high altitudes. In the southern United States, unless shaded or planted on northern slopes, they fail because of the long, warm summers.

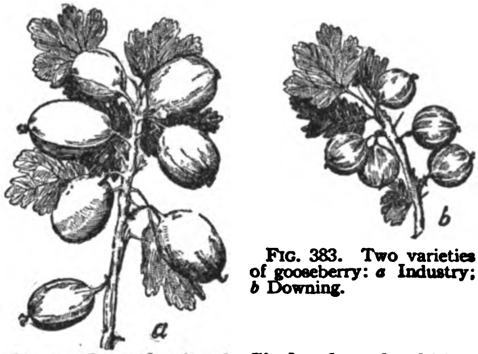


FIG. 383. Two varieties of gooseberry: *a* Industry; *b* Downing.

How grown. Propagation by mound layering is a more satisfactory method for amateurs than by cuttings. When placed in dry soils, the leaves fall early and the fruit often scalds. As the plants start growth very early in spring, they should be planted in the fall after their leaves have dropped. Usually the bushes are spaced 4 by 6 feet apart.

Clean cultivation is necessary. It should be shallow to prevent destroying the roots which feed close to the surface. Severe pruning must be done each year or the bushes will become clogged with stems, and small fruit and mildew will probably result. Three to 5 main shoots are enough to leave each year. When these have fruited 2 or 3 times they should be cut *out as soon as possible after the fruit has been harvested*, and burned, in order to maintain a constant supply of young wood and get rid of borers. Inferior shoots that spring from the base of the stool should be cut out, and straggling growths in the top cut back to keep the bush symmetrical. The fruit is borne on wood that grew the year before and on spurs, so some may be expected the year after planting the bushes. Full crops begin the fourth year and continue for 10, 15 or even more years, provided the plantation is given proper care. An average yield is about 3,000 quarts to the acre, but commercial growers have often produced 10,000 to 15,000. At the Central Experimental Farm in Ottawa, Canada, 6 bushes of Pearl set 4 by 6 feet apart, yielded in one year at the rate of over 21,760, quarts, and made an average of 9,920 quarts during 5 years.

GOOSEBERRY, Southern. A small shrub, native to southern United States resembling the blueberry more than the gooseberry. Its sweetish slightly tart, purple-fleshed, black-skinned berries are sometimes used for preserving.

GOUMI, a Chinese shrub 6 to 8 feet tall. Because of its hardiness and its ability to shift

FIG. 384. Bundle of grape cuttings

for itself, it is recommended for planting in cold climates where there is a lack of other fruits during early summer. The fruits are oblong, scarlet, or yellow, acid, gooseberry-like and about ¾ of an inch long. They are said to make excellent jam and jelly.

GRANADILLA. The edible fruits of various widely-distributed species of passion-flower vines native to tropical countries and cultivated there and in subtropical climates. The common granadilla, a luxuriant ornamental climber much used for covering arbors, has fragrant flowers and oblong, perfumed fruits often 6 inches in diameter. Their slightly acid pulp is eaten raw with sugar. The apple-fruited granadilla or *calabash* is only about 2 inches in diameter. Its hard rind is often made into trinket boxes. The water-lemon, Jamaica honeysuckle, or laurel-leaved granadilla has fruit the size of a hen's egg with slightly acid juice which is generally sucked. These species are common in the Florida Keys and the nearby mainland, and may be cultivated in the warm southern states westward to California. They are easily grown.

GRAPE. The grape includes less than 50 species of woody, climbing vines, of which more than 20 are native, each in its own area, from Canada to tropical America, and from coast to coast. All of the important cultivated varieties of Europe belong to one species supposed to be native to Palestine and other Mediterranean countries, and grown from the dawn of history mainly for wine, secondarily for raisins, and to a much less extent for dessert and cooking purposes. American kinds, on the other hand, are grown mostly for dessert, to some extent for wine and grape juice, less for cooking (principally jelly making) and scarcely if at all for raisins.

European types. For more than 200 years, scores of attempts were made to grow European varieties in America but always without success, even at the hands of vineyardists already skilled in handling the plant in Europe. Not until late in the last century were the three main causes of these failures positively identified as an insect known as *phylloxera*, and the diseases *mildew* and *black-rot*. The phylloxera, a species of aphis or plant louse, completely destroys European vines, but does little damage to American vines. Hence in growing European vines in sections where this pest is, the safest plan now known is to graft them on American stocks. In the early days of the California Missions, the European grape was introduced on the Pacific Coast. As the climate there is more favorable to it, and as neither phylloxera nor mildew were native there, success was gained very easily. In fact, some plants escaped from cultivation and are now found growing wild in many parts of the coastal states. When native American species were introduced, however, the native pests went with them so that now even there the European grape is not safe on its own roots but must be grafted on roots of American species.

Early in the 1800's, vines of American species (mostly of the "fox" grape type) began to attract the attention of cultivators, though from the Colonial days, quantities of wild grapes had already been used for dessert and wine. The red *Catawba*, the oldest variety grown to-day, was introduced by John Adlum, who published the first book on American grape culture and who was the first to recommend dropping European varieties and developing native varieties from the wild species. The next great American variety to appear is the dark blue *Concord*, introduced by Ephraim W. Bull about 1850. Mainly upon its general utility, it has played the leading part in American grape growing. Probably several times as many acres are planted to it, several times as many tons of its fruit eaten raw or converted into juice as of all other American varieties put together. It is only medium in quality, but it adapts itself to any well-drained soil, is comparatively free from disease and insect attacks, has abundant cropping ability, and produces large bunches of handsome fruit. Among other prominent varieties of this species are: *Moore Early*, *Moore Diamond*, *Niagara*, *Worden*, *Vergennes*, *Campbell Early*, and *Green Mountain*. Hybrids between this species and the European grape include such splendid sorts as *Agawam*, *Salem*, *Lindley*, and *Barry*. Several other species of American grapes are slowly attracting attention. Those that have given varieties of commercial importance are: (1) the Sumner, bunch, or pigeon grape which has produced a few varieties suitable for wine-making—such as Norton, Hermann, Cynthiana; (2) the post-oak grape which has

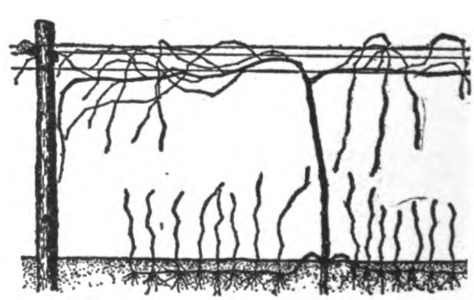


FIG. 385. Grape vine showing layering, in which two canes are bent down and covered with soil, which causes the joints to develop roots.

given some promising varieties like Beacon, Bailey, and Fern Munson; and (3) the Muscadine of the South including among others the famous Scuppernong and James. Several of the best species have so far scarcely been touched. When they and others have had another half century's work put upon them, our grape industry will probably be as far in advance of its present status as that excels conditions of 50 years ago.

Where grown. Among the most important American grape-producing sections are the shores of lakes Ontario and Erie in western New York and nearby Ohio, Pennsylvania, and Ontario; the "Finger Lake" region and the Hudson Valley in New York; the eastern shore of Lake Michigan; parts of New Jersey, Delaware, the Carolinas, Georgia, and Alabama; and the Ozark section of Missouri and Arkansas. In each of these, gluts are frequent, mainly because American grapes have limited secondary uses. Still during a series of years, the average net returns should equal or exceed those of ordinary staple farm crops.

Grapes may be grown on any kind of soil, but well-drained loams with good air drainage and free from late spring frost give best results. For wine-making, many manufacturers insist that the grapes be grown on clayey loams because the fruit is more regular and uniform and has a higher percentage of sugar. The margins of lakes and rivers, where the soil has been formed by the washings of the hillsides and is deep, rich, and well drained, give best results in eastern America. Plenty of sunlight and air are essential, both because they make for high quality, and because they help prevent disease.

Planting. Fall and spring planting are about equally popular. The former should usually be preferred when the vines can be secured in dormant condition at least 2 weeks before the ground freezes. One-year and two-year plants are about equally popular. When planted the tops are cut back to 2 or 3 buds, and the roots often shortened somewhat. When the buds start, only 1, or perhaps 2, are allowed to grow. The shoots are staked, or in large vineyards, allowed to sprawl on the ground. In the spring of the second year, the canes are cut back to 2 or 3 buds and as before only the strongest cane or two allowed to develop upon the stake. In the second autumn or the third spring, the canes are cut back and fastened to the lowest wire of the trellis if the upright system of training is used; or if strong enough to be used as the main trunk, for the Kniffin system. Usually, however, the main stem is not strong enough for this until the close of the third year in the vineyard. In the actual planting of a vineyard it is well to have the trellises parallel with the direction of the prevailing late summer and autumn wind so it will blow between, instead of against the rows. In most of the eastern vineyards, the rows are made 8 feet asunder and the vines set 6, 8, or 10 feet apart in them, depending upon the habit of growth of the variety. The holes should be about 15 inches in diameter and deep enough so the roots will just touch the bottom when held so the collar (or point where the stem begins) is an inch or so below the ground level; with well-grown two-year plants this will be about 8 inches. Plants with deep roots can better withstand drought. Surface soil should be placed around the roots till the hole is nearly full and the subsoil applied on top. If the soil first put in has been well enriched with bone, etc., so much the better, as grapes can hardly be over-fed. Best practice keeps the soil well tilled until midsummer or somewhat later, when a cover crop is sown for plowing under the following spring. The first year or two, peas, beans, early (not late) potatoes and other small-growing crops may be planted between the rows and the vines, but when the trellises are put up this should stop.

FIG. 386. Rooted grape cutting, showing where to prune in planting. (With Figs. 381 to 387 from Farmers' Bulletin 471.)

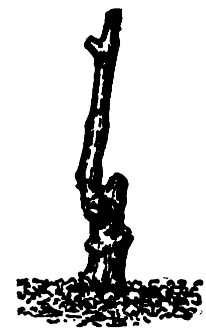


FIG. 387. Vine pruned at end of first year

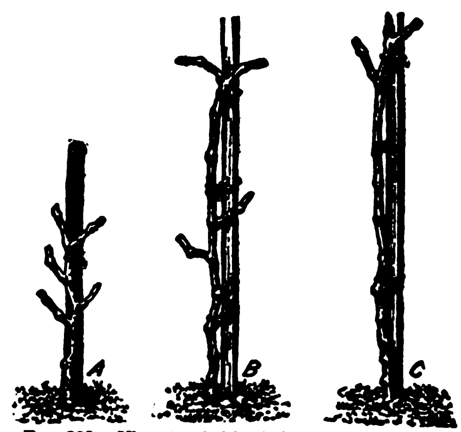


FIG. 388. Vines headed back for different systems of training: *a* spur and fan systems; *b* four-arm renewal; *c* two-arm Kniffin, Munson, umbrella, and overhead systems.

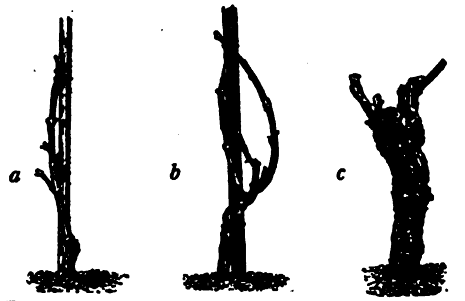


FIG. 389. Pruned vines: *a* third year and *b* fifth year, cane system; *c* fifth year, spur, stool or short system

Pruning and Training

In order to prune the vines intelligently, it is necessary to know that the fruit clusters are developed on shoots that grow this year from buds that have wintered over from last year. With this principle in mind, any man may work out a system of pruning and training to suit his conditions. He should also (1) remember that pruning is necessary to reduce the quantity of wood lest the yield be small and inferior; and (2) that he must keep the vine within bounds, out of the way of tillage tools and off the ground so as to give it light and air, both of which are essential to the production of high-quality fruit. Not every bud that winters over will produce fruit; puny ones certainly will not. It is customary among vineyardists to calculate upon 2 or 3 clusters to each plump bud they leave and to leave from 15 to 30 or perhaps 40 buds to each fully-matured vine. Thus they get from 30 to 100 clusters weighing 10 to 15 or even 25 pounds to the vine. Canes that are very rank, long or slender will not usually produce as well as well-ripened smaller ones of normal size and development.

Renewing. Unless watched, the bearing wood will grow farther and farther away from the main trunk. The aim is to arrange so that while one shoot is bearing a crop, another is being developed near the trunk to replace it the following year. After having fruited, the former is cut entirely off close to the trunk. This is called the renewal system whether the cutting be back to the trunk or to the root. One modification of the system uses "spurs" or branches cut back to 2 buds only, one of which is allowed to grow into a fruit-bearing cane. In time, when these branches become very gnarly and weak, a new shoot is encouraged to grow near the base of the spur which is cut off entirely. The renewal in such cases is only back to the arm of the vine. When the vines are trained on arbors, a main trunk should be trained to the top and the lateral canes annually cut back to spurs bearing only 2 or 3 buds.

Commercial systems. Popular commercial systems of pruning renew annually to the main trunk which is kept short—1 to 3 or 4 feet usually. Each year one cane, or sometimes more, is developed. Thus the bearing part is kept close to the main trunk without using spurs. The beauty of this system is that it can be kept up for years without unduly increasing the size of the trunk. One popular method, called the upright system, stops the trunk at the lowest trellis wire and forms a T with two canes at right angles to it. In this system, the shoots are tied to the two upper wires. In the other or Kniffin system the trunk is allowed to reach the top wire so the shoots hang downward; they are not allowed to attach themselves to the wires. Both systems have their stanch supporters, A third system, known as the Munson, has 6-foot posts with T cross pieces at the tops and a wire at each end of the cross arms. A third wire is attached to the post 6 to 12 inches lower. The trunk is trained to this lowest wire and made to develop 4 canes, 2 to extend on each upper wire. The annual pruning given after the vines come into bearing is done in the winter, preferably in January or February, though sometimes earlier. If delayed until spring, the vines "bleed." Whether or not this is injurious is disputed; the main objection to spring pruning is that the buds being soft may be injured at that time. Besides it interferes with plowing, spraying, and other spring work.

Trellising. In building trellises, some growers set the posts and one wire the second spring; others wait until the third spring when they build the trellises complete. The line posts should be 8 or 9 feet long and 3 to 5 inches in diameter; the end ones somewhat longer and 5 or 6 inches in diameter. In frosty localities, the posts should go lower than the frost-line—usually about 36 inches. Usually 24 to 30 feet between posts is sufficient with 3 vines between each two posts. If the rows are 100 or more feet long, the end posts should be braced. In the upright system, the lowest wire is usually placed 24 to 36 inches from the ground, the second 18 to 24 inches higher, and the top one (if there is a

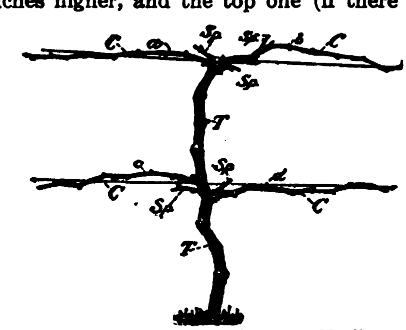


FIG. 390. Vine pruned by four-cane Kniffin system: C canes; *Sp* spurs (cut to 4 eyes); T trunk; *a, b, c, d,* canes that will bear and then be cut back making way for others.

third) 15 to 18 inches higher. Most commercial vineyardists use only 2 wires, 30 and 60 inches respectively from the ground. The wires should be wound twice around one of the end posts and the end twisted over the horizontal part. They should then be fastened with 1½-inch staples to the other posts but not so tightly they will not "give." It is best not to draw the wires very tight or to fasten them too firmly to both end posts because of their contraction in cold weather which may pull the end posts out of plumb or even out of the ground. About 180 posts, 500 pounds of number 9 wire and 3 pounds of staples are needed to the acre. With proper attention to pruning and other details, vines will produce as well upon arbors, buildings, fences, walls, or stakes as upon trellises.

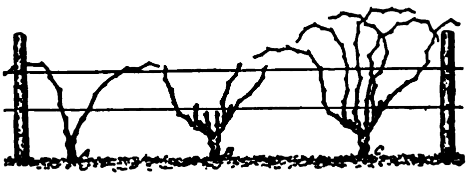


FIG. 391. Fan system of pruning: *a* vine in its third year unpruned; *b* in its fourth year, pruned; *c* fourth year unpruned.

Cost and returns. The cost of growing a vineyard in the East is figured about as follows: *First year*, $150, including cost of land; *second*, $55, including posts and trellises; *third*, $40, including baskets; *fourth*, $60. Some returns should come the third year, say, $50. From the fourth year forward the gross income should be $85 to $100 an acre or about $35 to $45 net. With proper care, the vineyard should last 15 to 25 years. Yields vary greatly among varieties but usually the small, high-quality grapes, such as Delaware, command high enough prices to offset their lighter yields. From 2 to 5 tons per acre is the general range with 6 and 7 tons exceptional. At prices usually paid for Concord, unless the yields average more than 4 tons an acre annually, the crop is not likely to be profitable in a commercial way. The census of 1910 shows 223,701,500 bearing vines and 59,928,600 young vines in American vineyards. The year previous (1909) the production was 2,571,065,000 pounds valued at $22,027,900. California led in production with 721,433,400 pounds valued at $10,846,800; New York was second with 253,006,300 pounds valued at $3,961,600; Michigan third with 120,696,000 at $1,531,000; Ohio fourth, 43,933,200 pounds and $858,600; Pennsylvania fifth, 34,020,200 pounds and $850,700. In no other state did the product of 1909 reach $500,000.

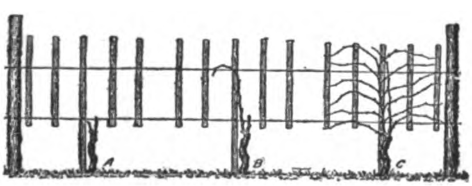


FIG. 392. Hudson horizontal system. Pruned vine, third year *a*; vine in its fourth year, unpruned *c*, and pruned *b*.

Propagating. In grape propagation seeds are used only to secure new varieties. The proportion of good ones is very small. Seedlings are often used by nurserymen for grafting, hardwood cuttings being most used. These are made at any time after the vines have dropped their leaves in the autumn. Green-wood cuttings of new and rare varieties are made during summer. Vines a year old or older are often cleft grafted while the scions are fully dormant; this work differs from that done on trees only in that the union is made below ground because of the flexibility of the vine. Usually no grafting wax is used but the soil is packed firmly around the grafts to prevent drying. Vineyards unprofitable because of the varieties planted may be grafted over to profitable ones either American or European.

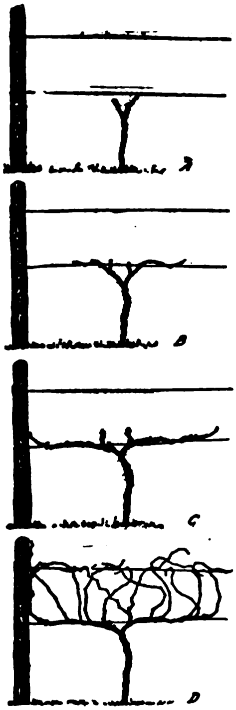


FIG. 393. Renewal system; *a*, *b* and *c* pruned vine second, third and fourth years; *d* unpruned vine, fourth year.

Handling European grapes. The methods of training and handling the European grapes are so different from those used in growing American varieties, and the area in which they succeed is so small, that would-be growers should secure publications of the United States Department of Agriculture and of the California and the New Mexico Experiment Stations before taking up the work.

GRAPEFRUIT, (POMELO, PUMMELO, SHADDOCK). A citrus fruit so named because its large, orange-like fruits often hang in clusters of 4 to 12 or even more, suggesting a bunch of grapes. Its slightly bitter, acid pulp has made it a very popular breakfast and salad fruit in the United States during the past 20 years. Though it appears to have been introduced into Florida by the Spaniards early in the 16th century, it was grown in America only in a very limited way until after 1890. In 1889

FIG. 394. A cluster of grape fruit

commercial plantings in Florida sent about 12,300 boxes to market, and California shipped 17,850 boxes. During the next 10 years the industry grew so fast that in 1909 the output, according to the United States Census, was 1,061,500 boxes for Florida and 122,500 for California. The value of the crop for the whole United States that year was more than $2,000,000.

Grapefruit growing has not increased as rapidly in California as in Florida because the Florida varieties are mostly unsuited to California climatic conditions and others more satisfactory have not yet been developed. The fruit of many inferior seedling trees has been marketed and thus injured the reputation of California fruit. However, the bulk of the western grapefruit is used west of the Rocky Mountains, where it does not actually compete with the superior Florida product. With properly chosen varieties, the industry should increase in California as well as in Florida.

Varieties in favor in California are *Marsh* or *Marsh Seedless*, *Triumph* and *Imperial*. Two other interesting growers are *Clayson* and *Nectar*. In Florida, the leading varieties are *Duncan*, *Hall* (*Silver Cluster*), and *Pernambuco*. More recent and less cultivated Florida kinds are *Walters*, *Bowen*, *Manville*, *Excelsior*, *Standard*, *McKinley*, *Jocelyn*, *May*, *Leonardy*, *McCarty*.

Where and how grown. The grapefruit tree is large, round-topped and very leafy. As it is more tender than the orange or lemon, its profitable commercial cultivation will probably not extend as far north as the frost line. Hence the selection of a frostless section is essential. The tree does best in a light, well-drained sandy or gravelly loam rather poorer than that favorable to the orange. On the other hand, the trees need liberal fertilizing when they come into bearing because this favors high quality.

Most trees are propagated by budding. They are set in the orchard from 20 to 25 feet apart when 1 or 2 years old. In 3 or 4 years from setting, they begin to bear and usually reach profitable age when about 10 years set. How long they will continue to bear is not known. Orchard management is similar to that of the orange (p. 337).

Citrus canker, an incurable disease, is the chief enemy. Burning the diseased trees is the only course.

GRAVIOLA, see *Annona*.

GUAVA, GUAYABA, GOIABA, GOYAVE. Several tropical American trees now widely distributed in warm countries. The best known species grow 25 to 30 feet tall, and bear globular or pear-shaped, usually yellow-

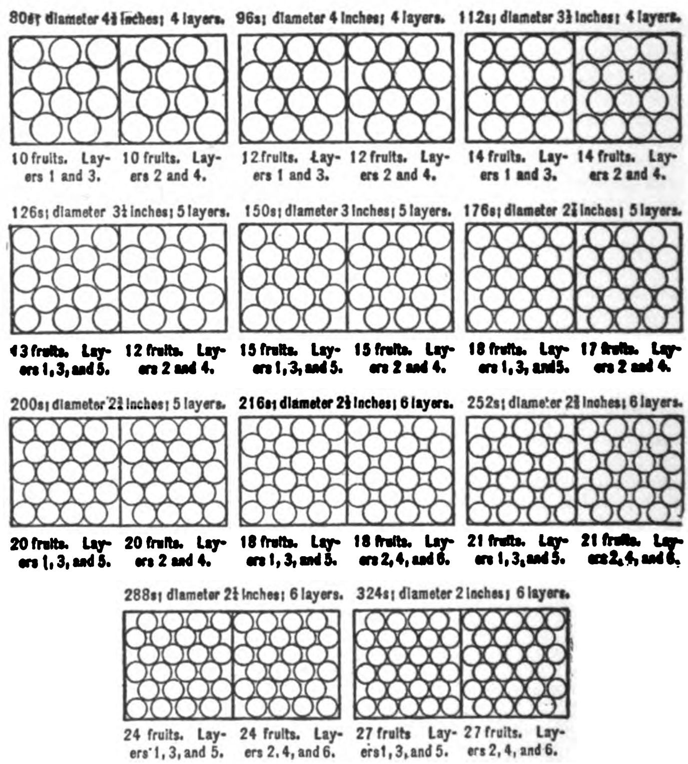


FIG. 395. Methods of packing grape fruit. (Farmers' Bulletin 696.)

skinned fruits 1 to 4 inches in diameter. Surrounding the small hard seeds are 2 layers of pulp, the outer granular, the inner, soft. The flesh varies in color from white to pink and salmon and in flavor from sweet to slightly acid, usually musky also. It is eaten out of hand, sliced with sugar and cream, in shortcakes and pies, stewed, preserved and, especially, as jelly and jam, in which last two forms it is of most importance commercially. Properly manufactured, these products are clear wine color, very firm and slightly musky. A thick jam, known as guava cheese, is made in the West Indies and Florida.

Varieties. The *Cattley* or *Strawberry* guava, a shrub 15 to 20 feet tall, is even better known than the common species. It is popular in California because it will stand up to 10 degrees of frost, and should be valuable in other parts of the South. The abundant fruit is pear-shaped, 1 to 1½ inches in diameter, maroon colored, yellow fleshed, very melting but not musky.

Where and how grown. Guavas are cultivated to some extent in California and Florida, and probably could be grown also in other warm parts of the South. In Florida, and elsewhere, it has escaped from cultivation and its seeds having been scattered by birds, it has become a nuisance. Though of rather slow growth, the tree may begin to bear when 2 or 3 years old from seed. It will do well in any well-drained soil.

Usually it is propagated from seeds but this produces variable fruits, so budding or grafting should be practised when choice seedlings are found or when a variety is to be perpetuated. Cuttings of half-ripe wood are easily rooted in greenhouse benches. In the orchard, the trees may be set 25 to 30 feet apart. Their cultivation is as simple as for any other orchard fruit.

HAZEL. Three native and several foreign species of shrubs or small trees with valued, edible nuts. Both groups are also called Filbert, which is properly the name of only the European sorts. The American species have produced no improved varieties and attempts to raise the European forms commercially in the East have failed mainly because of a fungous disease that kills the branches. In the Pacific Coast states there has been more success but the plant offers few attractions as a cultivated crop. For those who want to try it, favorable conditions are, apparently fairly rich, well-drained soil, freedom from mild spells in winter and late spring frosts (the fruit buds are quick to start and easily frosted), and careful pruning and thinning. Trees may be grown from stratified seed suckers or layers and should be set 10 to 20 feet apart, well cultivated and fed. Gather nuts when ripe and just before they begin to shatter.

HICKORY. The name of about 10 species of native trees found from Maine to Mexico.

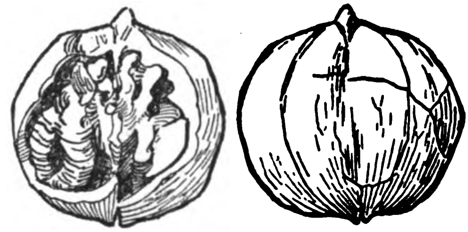


FIG. 396. Shellbark hickory nuts

and also the nuts of most of them. Except for one species—the *Pecan* (p. 347)—they have not been domesticated, though both timber and nuts are valued. This is probably because (1) forests and fence-rows have always supplied the demand, and (2) the tree is slow (10 years or more) to come into bearing. All the species can be propagated by stratified seeds—seedlings being transplanted when 1 year old, and set 50 feet apart in deep, fertile, well-drained soil, mulched, etc.—but the chances of good results and even of making the seedlings grow are small. Budding and grafting are even harder and more unsatisfactory. Perhaps the best way to get new trees from one of known value, is to cut, turn upward and support in that position some of the side roots, which will send out shoots, one of which will make a trunk, when the young tree may be transplanted.

Characters to be sought are, in the nut: easy cracking and removal of kernel with the least breakage; thinness of shell; plumpness and fine flavor of meat; and, in the tree, productivity. The *Shagbark* and the *Shellbark* are the choicest species, the first producing nuts with less shell in proportion to the meat, the second being a more thrifty, symmetrical tree, better fitted for ornamental purposes. The pignut is inferior to both, but has given one worthy variety—*Brackett*. Varieties of the other species worth naming are: Shagbarks—*Woodbourne, Curtis, Kentucky, Vest, Dover, Swain, Eliot, Mulford, Hales* (*Hales's Paper Shell*), *Jackson, Meriden, Kirtland, Rice*, and *Leaming;* Shellbarks—*Rieke, Meeker*, and *Lefevre*. These are nearly all seedlings. As good trees as can be bought from nurseries are probably growing wild in many places.

HONEYSUCKLE, JAMAICA, *see Granadilla.*

HUCKLEBERRY, *See Blueberry.*

ILMA, *see Annona.*

JALISCO, *see Annona.*

JAMAICA PLUM, *see Jew Plum.*

JAMBOLAN, JAMBOLAN PLUM, an East Indian shrub with edible berries sometimes as large as pigeons' eggs. Like the Jambos it is used for jelly making.

JAMBOS, JAMROSADE, ROSE-APPLE, an East Indian tree 20 to 30 feet tall valued for its blushed white or yellowish, rose-scented, apricot-flavored fruits which make excellent

FIG. 397. Washing and sorting lemons direct from the orchard

jelly. It can be cultivated out of doors in the United States only in the warmest parts from Florida to California.

JAMROSADE, *see Jambos.*

JEW PLUM, POMME CYTHERE, HEVI, SWEET OTAHEITE APPLE. A 50-foot tree a native of the Society Islands in the southern Pacific Ocean whence it has been widely distributed to warm countries. The plum-like, golden fruits resemble the pineapple in flavor. Its near relatives—the Golden Apple or Jamaica Plum, and the Spanish Plum—are natives of the American tropics. All three may be cultivated in favored locations from southern Florida westward to California.

JUJUBE. Several European shrubs and small trees grown in mild climates for their fruit and ornamental foliage. They succeed in any well drained soil. The red or yellow plum-like fruits are eaten raw, dried, cooked, and in confections. For such purposes the plant promises to be worth trying in orchards perhaps as far north as Virginia where some of the species have proved hardy.

JUNEBERRY, SHAD-BUSH, SERVICE BERRY. Common names for several related species of shrubs and trees which bear in early summer, red or purple, sweet, moderately juicy berries. They are chiefly valued for their generally white flowers which appear in profusion in very early spring; but also for their fruits which are generally eaten out of hand, though often with sugar and cream. All the species are hardy. The dwarf kinds are best for home use; the tall ones may be planted near fruit gardens to attract birds which will leave strawberries and cherries to get them.

KAKI, *see Persimmon.*

KUMQUAT, KINKAN. A dwarf, small-fruited Japanese species of citrus fruit. The shrub, which seldom exceeds 8 feet in height, bears an abundance of yellow fruits, either globular (½ to 1 inch in diameter) or elongated (1 to 1½ inches). When eaten raw the fruit is eaten skin and all, but it is mostly used for making marmalade and candied preparations. Grown in a flower pot, the kumquat makes a highly ornamental house plant. A light, sandy loam suits it best. In the orchard it is managed like the orange (p. 337).

LEECHEE, *see Litchi.*

LEMON. A tropical and subtropical citrus tree of which the familiar yellow fruit is valued for its very acid pulp. It is believed to be a native of India, and to have been introduced into Spain by the Arabs in the twelfth or thirteenth century.

Varieties. In Florida, the leading variety is the *Villa Franca* which has proved to be hardier than *Eureka*, *Genoa* or other varieties also grown commercially. The *Rough* lemon which grows wild in southern Florida is marketed to some extent locally but its chief use is to supply seedlings upon which to bud other citrus fruits. As home varieties, the *Everbearing* and *Ponderosa* are fairly popular, the latter especially because of its ornamental fruit which resembles that of the grapefruit (p. 329). These varieties are grown almost entirely on sour orange or rough lemon stocks, depending upon the character of the soil.

In California, the leading 6 varieties are *Eureka*, *Villa Franca*, *Lisbon*, *Bonnie Brae*, *Messina*, and *Genoa*, though the first three are by far the most important and the first the only one that is being extensively planted.

Where grown. The lemon is grown in warm climates throughout the world. In the United States it is most grown in southern California and over small areas in the states bordering the Gulf and Mexico. In Florida it was a leading crop until the freeze of 1894-5. The annual yield had been about 140,000 boxes, but by 1902 it had dropped to only about 1,000 boxes. Conditions have been improving, however, as shown by the census report for 1909 when 12,360 boxes, valued at $13,750 were produced. California's crop that year was 2,756,220 boxes valued at $2,993,700. Lemon anthracnose which makes brown spots on the fruit especially after harvest, has greatly injured the Florida industry.

LEMON VINE, *see Gooseberry, Barbadoes.*

LEMON WATER, *see Granadilla.*

LIME. Two species of citrus trees, one bearing sweet, the other very acid fruit. The former, though grown and used in other countries, has no commercial value in the United States; the latter is found wild and cultivated in the West Indies, the warmer parts of the Gulf States and westward to California. In the latter state, it has little commercial value because it is more tender than either lemons, oranges, or grapefruit. It can be cultivated only where frost never comes, though a cross between the lime and the Kumquat (above) called the Limequat, is hardy enough to be planted with safety wherever other citrus fruits will thrive.

Varieties. Among the leading varieties are

Persian, *Tahiti*, *Thornless*, *Imperial*, and *Beaoss*. *Everglade* and *Palmetto*, two new varieties, originated by Dr. H. J. Webber of California, have not yet been planted commercially, but are very promising. Where the true lime will not thrive because of cold, varieties of the Calamondin, for example, *Rangpur*, may be planted instead.

LIMEBERRY, BERGAMOT LIME. A small prickly evergreen shrub cultivated in many tropical countries as a hedge or ornamental plant and for its round or oval red berries. These are pleasant to eat raw or preserved. In America the plant is grown only in hothouses and the warmest parts of Florida and California.

LIME, SPANISH; GINEP. A West Indian tree 20 to 60 feet tall valued for its plum-like, green or yellow fruits which suggest grapes in flavor, and for its seeds which are sometimes roasted like chestnuts. As the tree will stand several degrees of frost it may be cultivated in favored parts of the southern United States.

LIMEQUAT, *see Lime (p. 332)*.

LITCHI, LEECHEE, a large evergreen Chinese tree widely grown in tropical countries for its fruits which consist of a thin, rough, brittle shell containing a sweet pulp

FIG. 398. Cluster of litchi fruits. (Hawaii Bulletin 44.)

and a hard seed. Chinese and Japanese stores usually sell them. The tree being very tender may be cultivated only in the warmest parts of the United States.

LOGANBERRY. A blackberry-like fruit believed to be a cross between the wild blackberry of California and a European red raspberry. It originated on the land of Judge J. H. Logan, of Santa Cruz, California, in 1881. It has since been planted extensively in all the Pacific Coast states and in British Columbia. Being very tender, it is not reliable even with winter protection where the temperature falls to zero. In the states mentioned, it is one of the best commercial fruits, as it is easily and cheaply evaporated and canned. When fully ripe, the fruit is purplish red, as large as a big blackberry, and its flavor and pleasant acidity suggest both raspberry and blackberry; before reaching this stage it is very tart.

Where and how grown. The plant will grow in any well-drained loam. It is propagated by cane tips. Vigorous rooted tips and 1-year-old plants give best results. Eight by 8 feet is none too far to set the plants in the field because of their vigorous growth. Some growers set them 4 feet apart in the rows and keep them headed back. The majority let the canes trail upon trellises like those used in grape growing (p. 326) except that Number 12 instead of Number 9 wire is used. Pruning and cultivation are the same as for blackberry and raspberry.

Yields. In good, moist soil and with proper care, yields of 14,000 pounds per acre have been secured, but a fair average is, probably, about 8,000. At the wholesale price of 4 cents a pound for canning and evaporating, gross returns range from \$160 to \$360 and net incomes from \$100 to \$300 an acre.

LOQUAT. A small, handsome evergreen tree native to China and Japan where, as in northern India, it has been cultivated for centuries for its fruit. The trees, which often reach 25 feet in height, bear large, dark-green leaves, small clusters of white, highly perfumed flowers in autumn, and in spring, globular or pear-shaped, plum-like, yellow to rich orange-colored fruits, often more than 2 inches in diameter. The flesh, which varies from melting to meaty, may be white to salmon colored. Its flavor suggests the sweet cherry. The fruits, therefore, are excellent for eating raw, also for making tarts, jams, jellies, etc.

Varieties. Many loquats are grown from seed but as there is much variation among the seedlings, grafting and budding on seedling stocks are practised with named varieties. Japan, California, and Algeria have originated most of the named kinds. The leading varieties grown in the United States are: *Advance*, *Champagne*, *Premier*, *Victor*, *Early Red*, and *Tanaka*. The loquat is such a splendid, easily-grown fruit and comes at such a desirable season—spring—that it should be in every home garden of the mild South.

Where and how grown. During the past 50 years, it has rapidly become popular in Mediterranean countries and in the semi-tropical parts of the United States from Florida to California. However, in all of this territory except the last, it is grown only as a home orchard tree or to supply local markets. In California there are commercial plantations. While the tree succeeds in any well-drained soil suited to other tree fruits, it gives best results on clayey loams.

FIG. 399. Cluster of the Champagne loquat and (*insert*) one fruit cut in half to show the seeds. (Calif. Bulletin 250.)

Trees should be planted 25 feet apart. Ordinary care is all they require—clean cultivation and cover crops, slight pruning to admit light, etc. Thinning is desirable to secure size, since the clusters are prone to set too many fruits.

Picking should be done for preserving while the fruit is still acid; but for eating raw it should be delayed until the specimens are ripe as they are then of best flavor and sweetness. As the fruit is rather soft, it cannot be sent far to market except in small packages such as berry boxes, and under refrigeration. Usually it is too highly prized locally to be shipped far.

MAMIN, see *Annona*.

MAMMEE APPLE or ST. DOMINGO APRICOT, a West Indian tree 40 to 60 feet tall which bears globular russet or brown fruits often 6 inches in diameter. The yellow, juicy pulp is eaten either preserved or raw with or without flavoring or sugar and cream. The tree may be grown along the Gulf of Mexico and to southern California.

MANGO. A beautiful erect or spreading tree often 70 to 100 feet tall, native to India and the Malay Islands, but cultivated in warm countries for its greenish, reddish, or yellowish fruit. This resembles the peach but is often 6 inches long. Its stone, which is nearly as long, resembles a watermelon seed but is covered with fibre that sometimes makes eating difficult; but this is offset by the deliciousness of the abundant juice—when the variety is a good one. If the fruit be inferior, its flavor may suggest a mouthful of cotton waste soaked in turpentine or kerosene or both.

Varieties. Mangoes are of several distinct groups of which the East Indian includes the choicest varieties, though some of the Philippine varieties are preferred by many people. Among the best now growing in Florida are *Haden*, *Paheri*, *Cambodiana*, *Mulgoba*, *Amini*, *Sandersha*, and *Bennett*. Some of these varieties, when budded, may begin to bear during the fourth or fifth year after planting, occasionally the third, but others require twice as long or longer.

Where grown. In tropical Asia, the mango is a more important fruit than is the apple in the United States. In India it is said to have been cultivated for 4,000 years and to have fully 1,000 varieties. In America, it is grown in all tropical sections as far north as Fort Myer and Palm Beach in Florida, but only in the warmest parts of southern California. The dry climate there is against it, stunting the trees. These are tender while young, but if protected until they get rough, thick bark, they will stand 2 or 3 degrees of frost for short periods without serious harm. While the trees grow large in deep, rich soils, they are not particular. In Florida they do well in the sandy soils underlaid by crumbly limestone. A dry season during blossoming and ripening favors yield and color. Small-fruited kinds often produce several thousand fruits, large ones only a few hundred annually. Yields, however, depend greatly upon the kind of weather during blossoming, since damp weather prevents the setting of fruits.

How grown. Budded trees are usually set 30 to 35 feet apart during April and May. Growth is favored by well-rotted manure in moderate quantities. Commercial fertilizers containing 3 per cent nitrogen, 10 per cent phosphoric acid, and 10 per cent potash have been found useful for bearing trees at the rate of 15 to 25 pounds to the tree, applied in spring, never when the plants are in blossom or in the autumn.

The fruit should be gathered when fully ripe, but before it begins to get soft, otherwise it will become jelly-like around the seed and unpleasantly flavored. Small pieces of the stem should be left upon the fruit when cut, to prevent bleeding; they drop off in a few days.

Mangoes are shipped from Florida to New York, Chicago, Boston, and other cities, in Georgia carriers each basket holding 6 specimens wrapped in paper and packed in excelsior. The *Mulgoba*, one of the principal shipping varieties, has paid growers $9 a crate. It ripens between late July and late August. Other varieties start to ma-

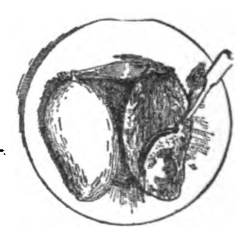


FIG. 400. Cecil mango; whole fruit (*left*); cut in half (*right*); seed, above.

ture in early July, and still others in September, so there is a season of about 12 weeks.

How used. While the mango is decidedly a dessert fruit, some varieties are best suited to cooking. In India, one of the chief uses is in making chutney relish and preserves. For this purpose and for making a kind of custard called Mango phul, the immature fruit is used. When the ripe pulp is spiced and dried in the sun, it may be used at all

FIG. 401. The mango tree is handsome as well as valuable for its fruit

seasons and exported to meet the demand in foreign countries. In South America and Cuba, jams and preserves, sherbets, and iced drinks are made from it. Canned mango is becoming popular, the fruit being put up like our pears and peaches.

MARITZGULA, *see Caraunda*.

MARMALADE TREE, MARMALADE PLUM. A tree of the West Indies, South America, and the Philippine Islands, of which the rough, rusty-skinned fruit is highly valued in warm countries for its edible pulp.` It grows wild in the Florida Keys and the nearby coast and may be cultivated in warm areas westward to southern California. A close relative called Ti-es or Egg Fruit, as cultivated in the same sections, makes a large evergreen bush or small tree which bears fruit about the size and shape of hens' eggs. Their flavor suggests egg yolk sweetened with sugar.

MEDLAR, MESPIL. A European shrub-like tree resembling a dwarf apple, but of which the fruit resembles the quince in not separating from the twig as do apples. The two leading varieties are *Dutch* or *Hollandish* and *Nottingham*, the former often 2½ inches in diameter, the latter about half that size, but of better quality.

While hardy as far north as Ontario, it is little grown in America. The fruit is hard and inedible until frost-bitten. Orchard management is like that of the quince (p. 352).

MIDSHIPMAN'S BUTTER, *see Pavocado*.

MULBERRY. A large tree or small shrub including a half dozen species native to temperate climates, some of them to the United States. The trees bear variously colored fruits which resemble blackberries. They are often planted as ornamentals and for silk-worm feeding; also for attracting birds away from berries and cherries which ripen at the same season. The fruits are sweet, rather insipid, good for dessert but of little use for culinary purposes, and of little if any commercial value. In some localities, they are valued as poultry and hog feed.

Varieties. *New American* (the *Downing* of most nurserymen), *Thorburn* and *Trowbridge* are the principal ones of the North and East. In some parts of the South, *Hicks*, *Stubbs*, and *Black Persian* are grown; and the latter also on the Pacific Coast. The silk-worm mulberry, a native of China, is the White mulberry whose fruits are white or violet colored and very sweet. The Red mulberry, a native American species, growing wild, usually on rich bottom-lands from Massachusetts to Texas and often 70 feet tall, bears red to almost black fruits of various sizes and often of excellent quality. *Lampasas* is one of its varieties. While some of these may not be hardy in cold and dry regions like the prairie states, the hardy Russian mulberries may be grown there; however, their fruit is decidedly inferior to that of the named varieties. Other varieties are usually worked on the Russian stocks. By planting several varieties, a long season may be covered.

How grown. A few trees may be set here and there to supply fruit for bird bait, for eating out of hand, for juice, jelly and jam, etc. The trees will thrive in any soil, even thin gravel and rocky lands. If possible, they should be planted 40 feet apart. Harvesting is done by jarring the trees so the ripe fruits will fall on sheets spread beneath.

MYRICA, a Japanese tree 40 to 50 feet tall, with evergreen magnolia-like foliage and plum-like fruits about an inch long. Two varieties have been grown in California, a dark red and a light rose-colored, finer-flavored one; and there are also black varieties. The fruits, which ripen in July, have a sweet but sprightly winey flavor and may be used like blackberries. As the tree is believed to be able to stand a temperature of 15 above zero, it should become popular for home fruit gardens throughout southern United States.

NASEBERRY, *see Sapodilla*.

NECTARINE, *see Peach*.

NEGRO-HEAD, *see Annona*.

NIGGER-TOE, *see Brazilnut*.

OLIVE. A small evergreen tree native to India and the Mediterranean region, cultivated for centuries for its oily fruits in these countries and more lately in the United States, South Africa, and Australia. In America, it succeeds only in southern California, lower Florida and favored parts of New Mexico and Arizona.

Varieties. The leading variety in California is the *Mission*, comprising more than half the plantings and used in making both oil and

pickles. *Ascolano* is the largest variety grown. Others are *Manzanillo No. 1* and *No. 2* (the latter rather small), *Sevillano, Macrocarpa, Obliza, Salonica, Regalis, Empeltre* and *Columbella*. Smaller varieties that, under favorable conditions, produce fruit large enough for pickling, are *Nevadillo blanco, Oblonga, Pendulina,* and *Uraria.*

Where grown. Olive trees do well in deep, well-drained loams, and will stand more dryness of soil than most other fruits, provided the roots can reach deeply into the subsoil for water. For profitable crops, the soil must be fertile, and good cultivation must be given. While the trees need more heat than do grapes, they will stand 10 or 15 degrees of dry frost for short periods when dormant. The distances needed between trees in orchards vary with the variety from 20 to 35 feet. As the trees are slow to reach maturity, many growers plant at the smaller distance with the intention of cutting out each alternate tree when the tops begin to touch at 25 or 30 years old.

Propagation. Olive trees are propagated by seeds obtained by placing the fully ripe fruits in piles until the seeds readily separate from the pulp. The stones are soaked for half a day to a day in a 10-per cent solution of caustic soda, care being taken not to have the liquid reach the kernel. (Cracking one now and then is a safe guide). After this treatment the stones are kept in moist sand till March or April, when they are sown. As the seeds of many of the large kinds are very slow to sprout, the tip of each stone is clipped off. Clipped seeds will germinate in about a month; unclipped ones may take a year or may fail entirely. Seedling olives are grafted or budded to named varieties the spring after sowing. They are believed to have better roots and to make more prolific trees than trees produced by cuttings which, nevertheless, are usually used in California, being made in January or February when the trees are dormant. Trees are planted in the orchard when 1 or 2 years old from the bud or graft.

Orchard management. Tillage, fertilizing and irrigation are about the same as for the orange (p. 337). While the trees will stand dryness, an ample water supply will insure better settings of fruit. Liberal irrigation in winter and spring, and frequent and thorough summer cultivation, give best results. Often it is advisable to give a heavy irrigation shortly before the trees bloom in March, April, or May and a second when the fruit is nearly full grown.

Pruning consists in removing badly placed branches at planting time and whenever they develop. Beginning the third year the lower limbs are cut off until a bare trunk, 2 to 3 feet long has been made. Other pruning consists in thinning out branches as needed each winter to admit air and light to the centre of the tree and to maintain good form. Trees so handled should be well formed in 5 to 7 years when paying crops should begin. After the trees reach maturity, California growers cut out 30 to 50 per cent of the small branches, especially those which bore fruit the previous season or which have made poor growth.

When olives are to be used for green pickles, they are harvested when fully grown but before they show any change of color. If older, they have an inferior color and sell at lower prices. For ripe pickles, they must become fully mature or they will not have the almost black shade demanded. When harvested too early, many will become red or yellow when pickled; if too ripe, they get too soft. Hence the fruit must be watched carefully from day to day. For oil making the stage of ripeness has much to do with both quality and quantity of product. The largest yields are secured from fully ripe, soft fruit; but the choicest quality of oil is produced from fruit harvested while ripe but before becoming soft. Hand picking is essential to prevent bruising; cloth-lined pails, baskets and bags are therefore used. Beating the fruit from the trees is not good practice, even for oil production, because, unless the oil is made immediately, there is danger of decay and mold getting into the fruit and injuring the quality of the product.

For pickling, the fruit is cleaned and sized by machinery as soon as gathered. The two larger sizes are pickled separately and the small one made into oil. After the bitterness has been removed by a solution of soda or potash lye, the fruit is hardened in a carefully made salt solution. A weak one may act very slowly on small varieties and may not wholly remove the bitterness; a strong one may soften the fruit and injure both its flavor and food value. For oil the ripe olives are allowed to dry slightly for a week or two before being pressed. They are spread 2 or 3 inches deep on trays in airy sheds and turned daily to prevent mold. Hop-drying kilns are used in moist climates so a temperature of 120 to 130 degrees may be maintained for about 48 hours. If warmer than this the oil may become rancid.

Yields and returns. Commercial olive growing is increasing rapidly in California. Reliable sources estimate the crop of 1909 as 3 times that of 1899. In 1912, the number of trees was estimated at 700,000 on about 14,000 acres. In 1911, the yield of oil was placed at 920,000 gallons, and that of pickled olives at 1,150,000 gallons. The average yield of olives was nearly 1½ tons to the acre. During the past 5 or more years, the price for pickling olives has ranged from $100 to $200 a ton. Thus the returns range from $150 an acre upward. A ton of olives sold as pickles at 75 cents a gallon means about $250; the same quantity turned into oil at $2.50 a gallon would mean scarcely $90. Nevertheless, in California only about 15 per cent of the crop

is used for pickling because most of the olives are not large enough or of high enough quality. Present plantings are of large-fruited, high-quality varieties rich in oil. The industry suffered a period of low prices as a result of the cultivation of poor varieties, insufficient understanding of conditions necessary for successful growth, cottonseed oil competition, etc., but these difficulties have now been largely removed.

ORANGE. A low-branching, evergreen tree, believed to be a native of India and China but widely cultivated for centuries in tropic and sub-tropical climates for its well-known yellow fruits. In many parts of the world, it has escaped from cultivation and become wild. The sour kind was introduced into Florida about 1513 or shortly after, for by the close of that century, it was well established as both a cultivated and a wild tree. At present, there are no commercial sour-orange orchards in the state. The sweet orange came later and was planted beside rivers and lakes which then formed the only avenues of transportation. Since the building of railways, it has become one of the most important crops of the state. In Louisiana, the orange has been cultivated in the lower Mississippi delta but extensive commercial groves were not planted till after the Civil War. Since the introduction of the *Satsuma*, a hardy variety, other areas along the Gulf Coast, and even half way northward in the state, have been planted.

In California, the Jesuit missionaries planted the first seedling orchard in 1804 at San Gabriel Mission, but not until 1841, when William Wolfskill planted two acres in Los Angeles, was a commerical plantation made. From this orchard, which gradually increased to 70 acres, he shipped in 1877, the first carload of oranges to the eastern states. Thomas A. Gavey started the first citrus nursery in 1865 also at Los Angeles. Large commercial plantings began when the Southern Pacific Railway completed its line in 1876. Another impetus was given in 1879 when the Bahia or Washington navel orange was exhibited at Riverside. The next and greatest development followed the building of the Santa Fe Railway about 1885. In other parts of the southern tier of states, are isolated areas where oranges are being planted, but so far they have not become commercially important.

In each of the principal regions mentioned, the industry has suffered seriously. Cold waves in 1886 and 1894-5 visited Florida, killed trees and ruined the industry in the northern half of the peninsula. In Louisiana, freezes in 1895 and 1899 did the same thing. The results of these freezes in Florida are that orange growing has disappeared in the northern counties, and developed in the southern ones. Also as in Louisiana, the trees are now budded or grafted upon hardier stocks.

In California, the high prices brought by oranges in the late '70's and early '80's induced

FIG. 402. Orange tree showing thick, bushy growth, and oranges borne all over the tree

speculation which was suddenly checked in 1882-3 by frost, drought, bugs, and improper marketing. By 1890, the industry was becoming normal and increasing at a healthy pace. Further impetus and steadiness have been given during the past 10 years by the California Citrus Exchange, a coöperative organization whose chief function is to distribute the fruit so as to avoid gluts and consequent low prices. It has been eminently successful. A similar but younger exchange is working well in Florida.

Varieties. The *Bahia* or *Washington Navel* orange mentioned above, introduced from Brazil in 1870 by the United States Department of Agriculture, is now the leading variety in California being grown on probably 80,000 acres. Only one other, the *Valencia Late* is still being planted for shipment. Among other varieties still shipped from old groves are *Paper Rind*, *Mediterranean Sweet*, *Ruby Blood*, and *Jaffa*.

In Florida, the *Navel* has not become prominent though *Valencia Late* is among the best known. Others are *Homosassa*, *Pineapple*, *Parson Brown*, *Ruby*, and *Luc Gim-Gong*. Among the Mandarin varieties, *Satsuma*, *Tangerine*, *Dancy*, and *King* are the leaders. In Louisiana, sweet orange varieties known to the trade as "*Louisiana Sweets*" and "*Creole Sweets*" constitute about 60 per cent of the orchards, *Mandarins* 20 per cent, *Navels* 7 per cent, *Tangerines*, 5 per cent, and miscellaneous about 8 per cent.

According to the census of 1910, the number of bearing orange trees in the United States was 9,738,000, and the number not bearing 4,327,000. The production of 1909 was 19,487,000 boxes or more than three times that of 1899. The value of the 1909 crop was $17,566,000 of which nearly 75 per cent

was produced in California, and most of the remainder in Florida. Production in the latter state in 1909 was about 18 times as great as in 1899, thus proving that Florida is recovering from the fear of freezes.

Propagation in the early days was wholly by seeds; to-day budding is the leading method. In various sections and for various soils and winter temperatures, many different seedling stocks are used—sour orange, trifoliate orange (a hardy species), rough lemon and grapefruit, the first two mainly because of their hardiness. These stocks are started from seed, sown like garden peas. When a year old and 6 to 15 inches tall, or when 2 years old and perhaps 2 feet tall, they are transplanted to stand a foot apart in nursery rows 4 feet apart. A year or two later they are budded, in Florida usually during the dormant season, in California in fall or spring. After the buds have grown one season, some trees are set out, but the majority are sold when 2 and 3 years old from the bud.

Planting. Distances for planting vary from 12 to 20 feet each way in Louisiana to 20 to 25 feet apart in Florida and California. The time of planting varies with the region. In Florida, some trees are set when the rainy season begins, but the majority between December and February. It is important that they get a good start before the dry spell comes in March. Thorough preparation of the soil precedes planting. It is important in orange and other citrus plantings to prevent exposure of the roots to the air even for a few minutes. For this reason many nursery trees in California are transplanted with balls of earth weighing 20 to 40 pounds. The trees must be set no deeper than they stood in the nursery, and the earth must be packed firmly around the roots. Soaking the ground around newly-set trees is an advantage because it aids in settling and packing the soil as well as supplying moisture.

Soils. In Florida, soils include high and low hammock, high pine and flat woods, and vary as to elevation and the character of their natural forest growth. When properly handled and when the right stocks are used, all these kinds may be used for citrus fruits. The main points are that they be thoroughly well-drained and well-supplied with humus. In California, the physical properties of the soil are considered of more importance than richness. Deep, uniform, well-drained, fertile soils are preferred whether the character be loam, adobe, sand, or rotted granite. Adobe soils are harder to work and irrigate than the others, but they give good yields. Shallow soils must be fed sooner or later. Hardpan and gravel are undesirable. In California, alkali is one of the dreaded ingredients of soils. The trees begin to fail wherever the content of alkali exceeds one fifth of 1 per cent.

FIG. 403. Washington navel orange grove in California. (Journal of Heredity)

Orchard management. Cultivation consists of annual plowing, clean tillage and the use of cover crops in all irrigated sections of California. In Louisiana, cultivation is given until the trees shade the ground, then only the weeds are destroyed.

Fertilizing. In Louisiana, commercial fertilizers containing 50 pounds each of nitrogen and potash and 25 of phosphoric acid are usually applied per acre of trees in full bearing. In Florida, fertilizers for trees not of bearing age usually contain 6 per cent each of potash and phosphoric acid and 4 per cent of ammonia; for bearing trees, ammonia 4 per cent, phosphoric acid 8 per cent, and potash 10 or 12 per cent. In California, there is no uniformity—2 to 40 pounds of mixed fertilizer to a tree may be used annually. Some growers apply it all at once before the ground is plowed in spring, others in 2 or 3 applications. Nearly all rely upon legumes to supply a considerable part of the nitrogen and vegetable matter needed, though stable manure is also used where obtainable. The favorite green manure crops in Florida are cowpeas, velvet beans, beggarweed, clover; in California, vetch is the leader.

Pruning in Florida and Louisiana consists mostly in the mere shaping of the trees while young and the removal of dead, diseased, or disabled branches in older specimens. In the former, the aim is to make the trees low-headed, spreading and well-balanced, because trees of this shape shade the ground and are easy to handle, especially during spraying and harvesting. In California, differences occur among varieties and growers and upon various soils. After being headed at planting time, Washington navels are scarcely touched during the first two or three years because they normally make good heads by themselves. About the only growths removed during this time are suckers. Valencia oranges grow more rankly and produce upright shoots which often become too long before branching. They are, therefore, pinched back to make them develop side branches. Bearing trees of both kinds are pruned according to the following general rules: Cut off all suckers not needed to replace other limbs removed, also

all over-vigorous, erect shoots that produce coarse fruit. Clean out brushy wood that is failing. Open the tops when necessary to admit light and air to the interior of the head so good fruit may be produced there as well as on the outside. Keep fruiting brush clear of dead twigs.

Valencia trees should have shorter limbs than navels, because they more often need to be propped. They are, therefore, pinched more to make them stocky and strong. Navels are rarely propped; Valencias usually are.

Frost protection is necessary in much of the area devoted to citrus crops.

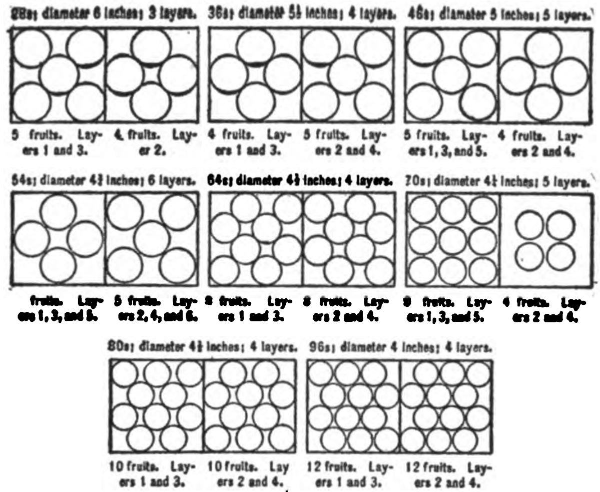


FIG. 404. Methods of packing oranges. (Farmers' Bulletin 696)

In general the amount of cold that citrus trees will stand varies with the kind of tree, the degree of cold, the variety, the dormancy of the top, the nature of the weather before and after the cold snap and the length of time the cold lasts. As thousands of acres of California orchards are in areas where frost damage has affected, or may affect, the crop or the trees, the orchardists have brought frost protection methods to a high degree of reliability.

In Florida, sheds, tents, and similar devices have been discarded except by amateurs because too costly and because trees so handled often fail to fruit. In both Florida and Louisiana, banking the soil high enough to cover the bud unions several inches deep is still popular. This protects the trunk so that, should the top be destroyed, a new top may be developed in 1 to 3 years from the latent buds in the trunk below the banking. In Louisiana, flooding with water from streams and ponds is not entirely successful though still relied upon to some extent. In all three sections, orchard heating is the most reliable method. In some cases wood or trash fires are built on the ground, but sheet-iron pots holding 3 to 5 gallons of low-grade oil, provided with covers to keep out rain, and drafts to regulate the size of the flame, are favored above any of the dozen or more patented heaters on the market. These heaters are worked so as to have the greatest amount of flame and the least smoke because the flame is hotter and the smoke smudges the fruit which must therefore be washed to make it marketable. It is found better to have many small fires than a few large ones. The heaters are, therefore, placed in the centres of the squares between each 4 trees, and an additional row on the windward side or sides. To make sure of an adequate supply of oil, each orchard should have a tank large enough to hold 5 or 6 times the amount of oil needed to fill the heaters, and this should be filled several weeks before the danger period arrives. With sufficient heaters and oil, the temperature in heated orchards has been maintained at 10 degrees above that in the near neighborhood.

Should the frost be allowed to affect the oranges, the skins may become spotted and softened on one side, and the pulp dry, pithy, and often bitter. This inferior fruit is culled out by passing the crop through a tank in which a current of water is maintained by a propeller. As the fruit falls about a foot from the end of an inclined slide, the injured ones come quickly to the surface but the sound ones rise slowly. The former, therefore, get above a wire screen set horizontally in the tank while the good ones stay below it. The current carries both grades to the far end of the tank where each is lifted to a separate line.

Irrigation is necessary in California. The amount of water needed naturally varies most with the age of the trees, and the kind of soil. One miner's inch continuous flow may be enough for 10 acres of full-bearing trees in one case, and for only a third of that area in another. Irrigations are given every 4 to 6 weeks during summer, and less frequently in winter. In clayey and other stiff soils, the flow may last 3 or 4 days at a time being distributed in 3 or 4 deep furrows between the trees. When a soil tube shows that at 5 feet depth the soil has become soaked, the water is shut off. On light soils, ridges are made around each tree to form large basins which are quickly filled by a large stream.

Harvesting. Orange trees should begin to bear in 3 or 4 years after planting and become profitable in from 5 to 7. In Florida and Louisiana, the harvesting season begins in October and ends in June, but is cut in two by the Christmas holidays when only small ship-

FIG. 405. Pawpaw tree. Wild trees often grow in thickets and take on a bushy form. (With Figs. 406 and 407, from Journal of Heredity.)

ments are made. Formerly much fruit was shipped green; but state laws now prohibit this. In California, the season continues throughout the year—Navels ripening from November to May, Valencias from June to November. Ripe navels in this state remain in excellent condition on the tree fully 2 months; Valencias 3 times as long or longer.

In all harvesting, the greatest care is exercised. The fruits are clipped, never pulled; gathered in canvas bags which open at the bottom so the fruit can be gently emptied into boxes. The skin must not be broken or decay will follow, hence cotton gloves are often worn to prevent even scratches by finger nails. Even a grain of sand in a box may break the skin and thus ruin a fruit. Some growers pick only the lower fruits first so as to have the rest above the frost-line should frost come. This also prevents the splashing of these fruits with soil during winter rains and consequent brown rot; likewise it relieves the trees of part of their load. Picking is now on a day-labor basis because less damage results when the pickers work slowly.

Grading. The fruit is hauled in spring wagons or trucks to the packing-house where it is stored for 1 to 4 or 5 days to shrink and toughen the skins somewhat. It is then passed through various machines such as a brusher to remove dirt, a washer to get rid of scales and soot, etc., and then on belts in front of graders who sort it into standard, choice, and fancy grades. These grades are automatically weighed and passed through a sizing machine which makes 8 to 10 sizes which are delivered to padded bins ready for packing. Each fruit is wrapped in branded tissue paper and placed in the shipping boxes. Some packers exceed 60 boxes in a day. The packed boxes are automatically carried to the cooling room or the refrigerator car. Some of the larger growers still sell their fruit direct, others sell on the tree, but the great majority sell through the California Fruit-Growers' Exchange which, organized in 1895, was reorganized 10 years later and now handles between 60 and 75 per cent of the citrus fruits shipped from the state.

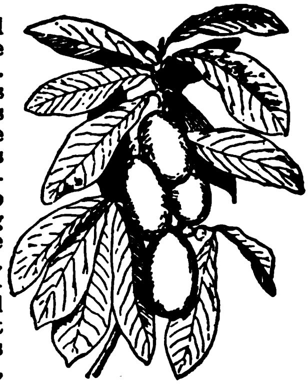


FIG. 406. Cluster of pawpaws

PARA NUT, *see Brazilnut.*

PAWPAW. Two American trees and their fruits; one (the *papaya*) is tropical and subtropical, the fruit being eaten locally, sometimes raw but oftener in sauces and conserves. The other is a native of Kentucky and southern Ohio, but grows singly and in groves in woods and pastures eastward to the coast, southward to northern Florida, westward to eastern Kansas and northward to central Michigan. The tree is small, usually shrubby, with large leaves that are shed each year. It is easily propagated by grafting or from seeds which should be soaked before planting. Late autumn is the best time for planting as the seeds die quickly if the ground becomes too dry. Good drainage is essential, and frequent cultivation together with the application of a rich mulch improves both the yield and the quality of fruit.

The tree is long lived and, beginning to bear 3 or 4 years after being set out, will yield from 50 to 100 fruits regularly each year.

The fruits (known also as *custard apples*) weigh from 7 or 8 ounces up to a pound, and are generally borne in clusters, sometimes as many as 8. If thinned so that only 4 or 5 remain, they become larger and better. The

FIG. 407. Pawpaw cut open showing the custard-like flesh and large, hard seeds

skin is green but turns brown readily if fruit is at its best, the flesh being creamy yellow and very soft, somewhat like a ripe banana. Because of certain medicinal properties, it is an aid to digestion and may be freely eaten raw, or cooked in various forms. (By P. B. Ruggles, Wyoming, O.).

PEACH. A tree fruit widely cultivated in temperate and subtropical climates, ranking next to the apple in commercial importance. When a peach pit or a bud from a peach tree produces a tree bearing a smooth-skinned peach, the fruit is called a *nectarine.* Thus one part of a tree may produce nectarines and the rest peaches. The treatment of both fruits is the same.

Types and Varieties. Prominent nectarine varieties are *Boston, Elrige, Humboldt, Advance, Dowonton, Hardswick, Lord Napier, Early Newington, Pilmaston, Orange,* and *Stanwick.* The nectarine is commercially important only in California.

Peach varieties are of 5 classes: (1) Peen-to or flat including *Peen-to, Waldo,* and *Angel* —scarcely grown north of the Gulf states; (2) South China, oval, long, pointed fruit with a deep suture near stem. *Honey* is the best known variety; (3) Spanish or Indian very late, firm, often striped, grown mostly in Gulf states. Varieties are *Lulu, Galveston, Texas, Cabler, Columbia,* and *Victoria;* (4) North China, large cling or semi-cling stone fruits. Varieties, *Elberta, Carman, Greensboro, Waddell,* and many others; (5) Persian, similar to (4) but mostly freestone. Varieties are *Crawford, Mountain Rose, Amsden, Oldmixon, Salway, Alexander,* and *Chairs.* The last two groups are much mixed and include the most important commercial varieties.

Soil and site. While the peach succeeds on a wide range of soils, it does best on well-drained sandy loams but stony and gravelly soils are also excellent. Lowlands, and eastern and southern exposures should be avoided if possible; the former are likely to be frosty, the latter so warm that the buds swell prematurely in winter or spring. In either case, the blossom buds are likely to be killed, injuring the crop more or less seriously. Ground 50 to 100 feet or more above the surrounding country should be chosen. Even 10 feet elevation may mean success instead of failure.

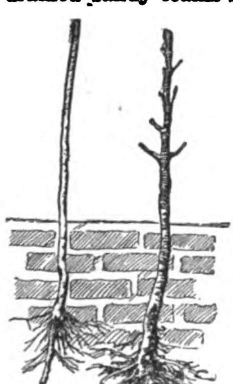


FIG. 408. Peach trees trimmed ready for planting. At *left,* 4 to 5 foot grade; at *right* 5 to 7 foot grade. (Farmers' Bulletin 631.)

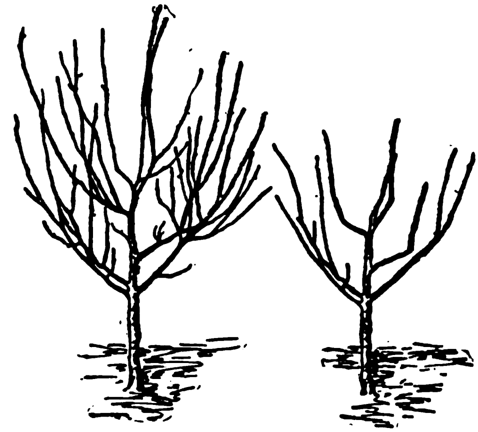


FIG. 409. Young peach trees before and after pruning. (Mich. Special Bulletin 63)

Propagation. Practically all peaches are propagated by budding desired varieties on seedling peach stocks the first summer from the pits. For planting on wet soil and for dwarfing, plum and cherry stocks are used to some extent, but these give trouble because of imperfect unions. There is little if any difference between northern-grown and southern-grown trees, provided development, freedom from insects and diseases, and other factors are equal. When planted, peach trees should have grown only one season in the nursery. "June buds" in the South produce trees suitable for planting in autumn of the same year, and fall buds in the North are ready 14 or 15 months later. To plant an old tree is to invite failure; only vigorous trees should be chosen, those $\frac{5}{8}$ to $\frac{3}{4}$ inch in diameter and 3 to 5 feet tall. Well-ripened trees may be set in the fall where the winters are not very severe and upon well-drained soils.

Planting. Commercial growers generally prefer 20 feet between trees. On hilly ground the trees may be set closer up and down the slope but farther apart in the other direction. For the first 2 or 3 years, inter-crops may be grown, preferably of vegetables that may be harvested in early fall without stirring the soil—peas, beans tomatoes, melons. A winter cover crop of crimson clover or rye and vetch may be sown without interfering with the vegetable harvest.

Cultivation. While the apple has sometimes succeeded under the sod-mulch method, attempts to grow the peach in this way have usually failed. The best management of mature orchards, plows or discs in the cover crop in early spring and maintains a loose, open surface until within 2 or 3 weeks of ripening or midsummer, when another cover crop is sown. Careful watch of the trees should be kept to prevent overdoing the legumes and thus getting too much wood. Nor should fertilizer very rich in nitrogen be

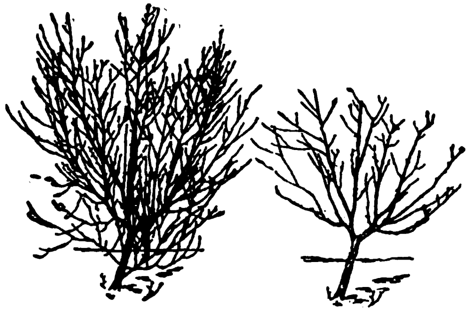


FIG. 410. Bearing peach trees before and after pruning. (Farmers' Bulletin 632)

used. Mature trees should make 12 to 18 inches of growth annually. To maintain such growth under average conditions, a fertilizer containing 100 pounds of nitrate of soda, 400 of acid phosphate and 150 of muriate of potash will be about right. Where the foliage looks yellowish and the growths short, additional nitrate may be applied.

Pruning. Some growers allow peach trees to develop almost naturally, merely thinning the branches enough to admit light and air, claiming somewhat earlier fruit production. Trees so managed, however, grow too wide and high, and are prone to break under heavy crops and loads of ice. Also the bearing area annually extends farther and farther from the trunk. Other growers cut back the annual growths 50 to 75 per cent and also thin out the branches and inferior twigs. Thus they secure well-formed, compact trees, much less likely to break. The reason for the success of this method is that the blossom buds are borne mainly near the bases of the one-year shoots in groups of 2 blossom buds to 1 leaf bud situated between them; sometimes the middle bud also becomes a blossom. Solitary blossom buds also occur.

The length of the trunk varies among growers from 6 inches to 3 feet or even more. Popular lengths are 15 to 24 inches since these make easy the digging out of borers without being too long. At planting time, the leader is usually cut to prevent the trunk from becoming too tall. The first season, every twig and leaf is allowed to grow. The following winter or spring, the 3 to 5 main branches are chosen for the framework. They should be as far apart as possible and extend in different directions. Severe cutting back must be avoided as much as possible because it delays bearing. To reduce the pruning needed the second winter, rub off during the second summer undesirable growths, while still small—2 to 4 inches long. The tips of the branches may also be pinched off at 18 to 20 inches if growth is becoming irregular. Summer pinching tends to hasten fruit bearing and to develop hardy growth.

From the second winter forward, pruning should reduce the side branches to those best placed, cut back the leaders, prevent the development of a central leader, and maintain the general form of the tree. When 10 or 15 years old, if the trees have become top heavy or too wide spreading, they may be cut back severely to wood 2 or 3 years old. The best time to do this is in the early spring of a year when the fruit buds have been killed. It is always risky to cut off main branches to mere stubs.

Thinning. When pruning is thoroughly done, it largely replaces thinning. But additional thinning pays more with the peach than with perhaps any other fruit because the peach is so largely used for dessert, and high quality always commands best prices. Thin soon after the "drop" or natural shedding of excess fruits. Most growers agree that the fruits should stand not closer than 6 inches apart; many prefer 8 inches.

Picking. For distant markets, peaches are gathered while still hard, but mature; pickers determine this stage by the color. Yellow varieties change from yellowish green to more pronounced yellow and orange toward maturity; white ones from light green to a creamy under color (beneath the red). In learning to distinguish this stage of development, the ball of the thumb may be pressed gently against the fruit which, if ready, will "give" slightly. Never use the fingers or the tip of the thumb because bruises will later become unsightly and start decay. For local market, the fruit may be much riper. In any case a twist will separate the fruit from the twig. On well-pruned trees, skilful pickers have exceeded 100 baskets of 16 quarts in 10 hours.

Grading and packing. For best results, grading and packing in a packing house are popular among large commercial growers because they save time and give improved quality and uniformity of fruit. The most convenient houses are long and narrow with a covered driveway and platform on one side for unloading the orchard-run fruit, and wide doors on the opposite for loading the finished product. Beside the platform are the grading machines, then a row of packing tables, kept supplied so the packers do nothing but pack. Behind them the nailers carry away the packages and fasten on the covers. The upper floor is used for making and storing crates, baskets, etc. Greatest speed is secured by proper arrangement so that the movement is all in one direction. Popular packages are 16-quart Jersey or Delaware baskets, Georgia "6-basket carriers," Michigan bushel and half-bushel two-handled baskets, Climax grape baskets and California boxes.

PEAR, a long-cultivated temperate-climate fruit, closely related to the apple. The varieties grown in America are mostly of European origin or descent, though a few have come by hybridizing these with the Chinese sand pear. So far, these hybrids, of which *Kieffer*, *Smith*, *Garber*, and *LeConte* are the leaders, are of

low quality compared with even average varieties of the European group. Perhaps the principal reason why the pear is less popular than a generation ago is that these hybrids have led people to believe that the pear is an inferior fruit instead of being, in its best varieties, one of the most delicious of all.

Varieties. Many varieties of pears are offered by uurserymen but there are a few, generally well-known and widely popular standbys for home or commercial orchards. Many varieties of pears are self sterile, that is, will not set fruit if planted with no other varieties near by. This is especially noticeable in the Bartlett. The degsee of sterility depends somewhat upon local and seasonal conditions. In planting, it is, therefore, a good plan to have not more than 5 rows of a kind together and to have equal numbers of rows of other kinds on each side. For home use, this precaution should not be necessary, because many varieties should be planted. Good kinds are numerous. The leader is the Bartlett which is the best general-purpose pear in the world. Kieffer, probably, ranks second, but it is so poor it should not be planted except where better pears fail. The standard of excellence is the small Seckel.

Where grown. The most important pear-growing sections of North America are the New England States, and areas near the Great Lakes, the Atlantic and the Pacific oceans. Failure is too frequent in the Mississippi Basin, in the Gulf States and in the prairie states to make commercial pear culture a safe venture. In the first case, blight is the main cause of loss; in the second, too great summer heat; in the third, too severe winters. In this last section, Russian varieties recently introduced promise success. Because it is far less cultivated commercially than the apple and because its best varieties are of even better quality than the best apples, the pear should be more generally planted in home orchards. Pear trees thrive best on clay soils almost too stiff for any other crops. On sandy lands, they are shorter-lived, perhaps because they grow so rapidly as to be more subject to blight. For this reason, also, the trees will not stand so much cultivation or so much nitrogen as other orchard trees. Hence stable manure, leguminous cover crops and fertilizers rich in nitrogen must be used with caution if at all in some years and on some soils. It is important that the trees have abundant unobstructed sunlight, also that no other trees or shrubs such as currants and raspberries be near enough to rob them of their plant food. In commercial orchards, standard pears should be set not less than 25 feet apart and dwarfs at least a full rod; 25 per cent more space may be allowed in home orchards. Properly handled trees, 1 or at most 2 years old when planted, should come into bearing in 3 to 5 years, and continue for a century or more.

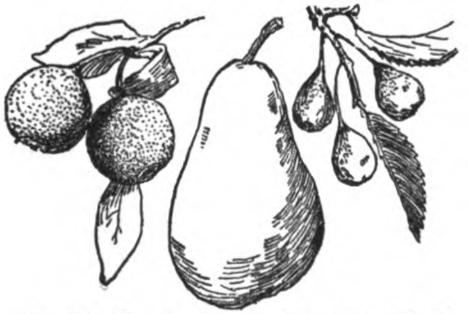


FIG. 411. How the pear has been improved. The wild pear (*left*) from which has developed the Bartlett type (*centre*). The Chinese sand pear (*right*) crossed with the Bartlett has given some desirable new varieties. (Journal of Heredity.)

FIG. 412. How flower buds (*left*) and leaf buds (*right*) differ in the pear.

Pruning. The management of a young pear orchard is the same as that of a young apple orchard (p. 303) except as above noted and in the training of the trees. Because of the susceptibility of many varieties to blight, which is believed to be most prevalent where the trees make strong, sappy growths, it is important that the trees be grown with the smallest number possible of twiggy growths on the trunk and main branches. Such growths, if attacked by blight, are very likely to allow infection to enter important parts of the tree and to result in heavy if not complete loss. If infection can be confined to small parts remote from the main limbs and the trunk, they can be removed promptly without threatening the more important parts. Some pear growers train their trees with 3 to 5 branches in a sort of vase form and without a central stem because they claim that if one of the limbs becomes infected, it can be often removed and a new one developed without losing the tree or throwing it out of balance. Equally successful growers train their trees to one central stem with many side branches so placed and spaced that all interior parts of the tree have abundant light and air and may be easily reached in case of necessity. Losses in such cases, they claim, are less than in the former method.

After the trees begin to bear, pruning must be governed by the method of flowering. Like the apple, the pear produces its flowers mostly upon spurs each alternate year, though some varieties, under certain condi-

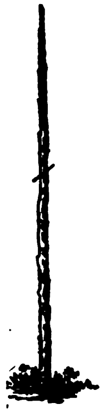


Fig. 413. One-year pear pruned for planting.

tions, produce blossom buds in the angles of the leaves. The spurs continue to branch and become gnarly and often weak as they grow older. When, through weakness, they begin to produce inferior or no fruit, they may be thinned out so as to turn the energy into more favored spurs. The first of such thinning will rarely be needed before the trees are 15 years old. After that a thinning once in 5 or 10 years will be often enough.

Renovating. Neglected pear trees, no matter how old, are quick to respond to proper treatment. Unless too seriously blighted in trunk and main branches, they will probably yield well for many years, even though only part of the trunk is living. Even if the trees produce inferior fruit, it may pay to save them for, in this case, it may be worth while to graft them to better varieties. Pear trees, because long-lived, are more satisfactory to renovate than apples or any of the stone fruits. In this work, the first thing is to remove and burn the dead and blighted wood. If the top is slim and spindling, cut it back 3 or 4 feet if there are many erect branches, more if there are only a few. This will not throw the tree out of balance but will stimulate growth of new wood. The next thing is to skin off any sod beneath the tree in a circle 3 to 5 feet wide as far out as the branches reach, and apply a heavy dressing of old pulverized barnyard manure or compost made rich with bone meal, tankage or other fertilizer rich in potash and phosphoric acid but not very rich in nitrogen. Work this in shallow without injuring the roots. Best results follow if this work is done in the fall any time before frost. If the trees have formed flower buds that season, they will probably bear well the next; whereas if the work is done in the spring, they probably will not. It is not essential to success to remove the sod beneath the trees when the orchard is to be cultivated, but fertilizing as indicated is necessary. In cultivating run the plow or disc very shallow to escape as many roots as possible.

Harvesting. Pears of different varieties begin to ripen in midsummer and may continue up to Easter. The winter varieties are little grown in the eastern United States, perhaps because they are slower to come into bearing and are less prolific than early-season varieties. They should be more generally planted in home orchards. When allowed to hang too long on the tree, and when stored in too warm quarters, they rarely keep beyond New Year's Day; but if gathered when just mature, and then stored like winter apples in a cold but frost-proof room, they will last all winter.

It is important to gather the fruit when the specimen will separate from the tree without breaking either its stem or the fruit spur which bears it. Pears so gathered and ripened off the tree indoors are of much finer flavor than those ripened on the tree. They should have reached full size and begun to color but not become soft. A cool, dry, close room will ripen them best. If the room be draughty, they will shrivel; if too warm, they may ripen too quickly and decay. In general, if picking is done a week or 10 days before they would naturally be ripe, they will be of best quality. If to be shipped under refrigeration, the fruit may be gathered riper than this. In shipping they must be handled more carefully than apples because they are more easily bruised. Many growers pack their best pears in boxes similar to apple boxes as follows: First, a layer of excelsior is put in the bottom of the box (which will later become the top); next a sheet of paper, then a single layer of pears, each wrapped separately in paper, then a sheet of paper, another layer of excelsior and so on until the box is full; then a layer of excelsior and the cover finish the job except for labeling. For lower grades and for general markets, half barrels and barrels are used in New York. While pears are preëminently dessert fruits, great quantities of certain varieties—notably Bartlett and Kieffer—are canned.

Dwarf pears. When pears are grafted or budded on quince stocks, the trees may be kept small by removing all roots that develop above the union of stock and scion and by proper pruning, cutting back all growths. Unless so handled, the trees may become semi-standard or even full standard. Among the advantages of dwarfs over standards are more trees in a given area, less danger of winds blowing fruit off, earlier bearing, ease of pruning, spraying and harvesting and larger, better quality of fruit. Varieties especially adapted to dwarfing are *Amalis, Angouleme, Autumn, Long Green, Manning's Elizabeth, Diel, Easter, Glout Morceau, Vicar* and *Louise Bonne*. Varieties that do better as standards are *Aremberg, Bartlett, Eté, Gray Doyenné, Lucrative, Onondaga,* and *Seckel*. Another list fail on the quince unless double-worked, that is unless one of the successful kinds is first worked on the quince and then the desired variety grafted or budded on this pear

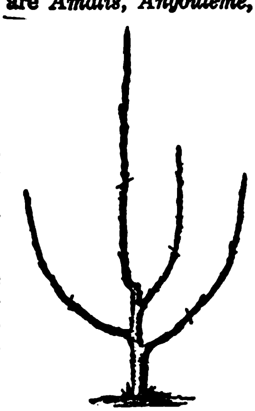
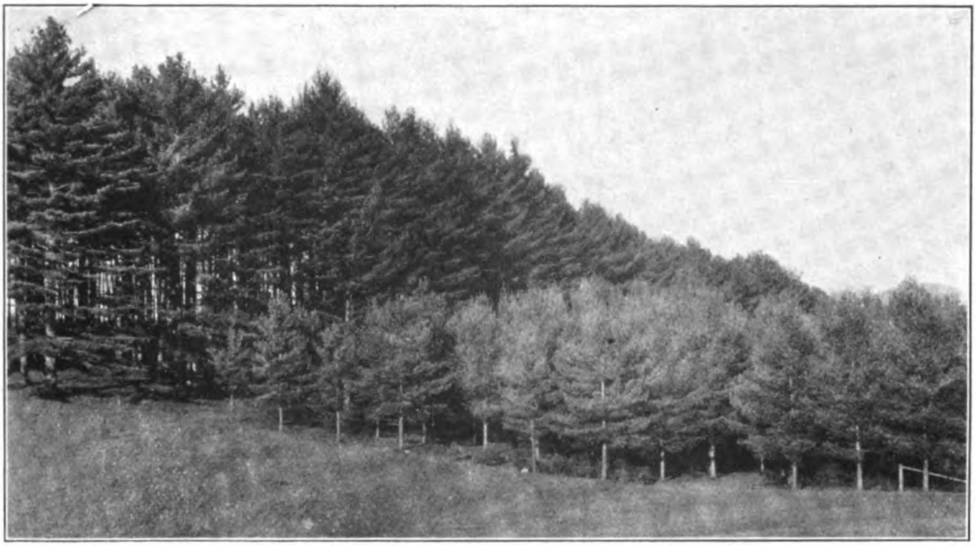


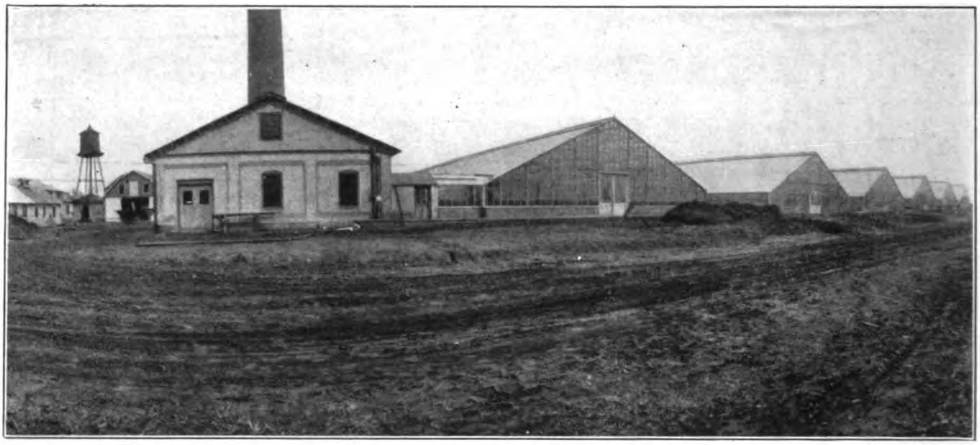
Fig. 414. Two-year pear, with cross lines showing where to prune back.



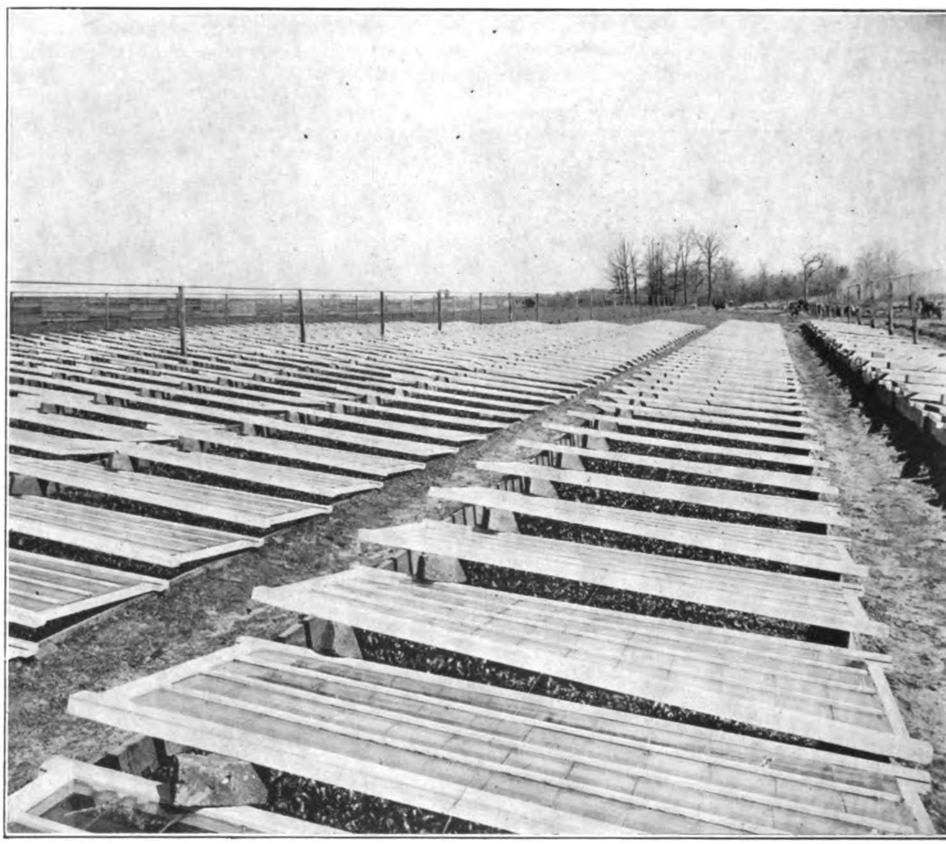
The farm woodlot should be, first, a source of firewood; next, a source of timber and lumber; and all the time a shelter against storms and winds

Like other by-products, maple sirup and sugar can be made a source of generous profit

FOREST ROBBING LIKE SOIL ROBBING HAS PLAYED TOO BIG A PART IN OUR FARMING. THE WOODLOT SHOULD BE VIEWED AND CARED FOR AS A PROFITABLE, WORTHY FARM CROP



Greenhouse management is outside the field of the general farmer, but in the growing of vegetables, flowers, and nursery stock it has been widely and wonderfully developed



Such a range of hotbeds is practicable only on a truck- or market-garden farm; but every farm should have at least one frame as part of its kitchen garden equipment

THE PUBLIC DEMANDS—AND PAYS FOR—FOOD PRODUCTS OUT OF SEASON. IT IS THE FARMER'S TASK AND OPPORTUNITY TO PRODUCE THEM

stem. These varieties are: *Bosc, Dix, Marie Louise Dunmore, Gansel's Bergamot, Paradise Sheldon, Washington,* and *Winter Nelis.*

More care is needed in managing dwarf pears than standards and they should not be planted unless the grower is willing to do this extra work. The trees must be placed so the union of stock and scion is 4 to 6 inches below the surface after settling of the soil, to prevent damage by quince borers in the root and breakage by wind. Training should start the first year and be given every winter thereafter. The lowest limb should be 15 to 18 inches from the ground, the others spaced at least a hand breadth apart. Where the cold is intense, it is best to postpone the pruning until March but to have it all done before the buds start to swell. Each good new growth of the previous summer is cut back to 4 and 8 buds and the poor growths removed entirely. Failing branches and others not needed for limbs are also removed at any time to admit air and light. Handled in this way trees 20 years or older should be kept about 12 feet high and spread 12 to 15 feet across the flattened top. Commercial dwarf pear orchards have been profitable for 50 years.

PECAN. This is the leading native American nut planted for commercial purposes, mainly because of its superior quality, thinness of shell, ease of cracking compared with other (related) hickory nuts, and the wide extent of territory in which different varieties succeed. Wild trees in Indiana and Illinois often reach 6 feet in diameter, 150 feet in height, and a spread of more than 50 feet. While the principal pecan forests are in the Gulf States, the trees are common in the woods of Kentucky, Iowa, Missouri, Indiana, and Illinois.

Varieties. As many mistakes have been made in the choice of varieties, Reed's classification (Farmers' Bulletin 700) is given here: Varieties for coastal Virginia and North Carolina: *Van Deman, Mantura, Moneymaker, Schley, Stuart,* and *James;* coastal South Carolina, coastal and central Georgia, central Alabama and Mississippi: *Moneymaker, Schley, Stuart, James, Carman, Van Deman;* south Georgia and north Florida: *Curtis, Bradley, Schley, Alley, Stuart, Moneymaker, Pabst, President, Russell,* and *Van Deman;* central Florida: *Moneymaker, Schley, Van Deman, Bradley, Curtis, Kennedy,* and *President;* coastal Alabama, Mississippi, and Louisiana: *Success, Havens, Pabst, Russell, Stuart, Curtis, Alley, Van Deman, Schley;* east Texas: *James, Carman, Stuart, Moneymaker, Curtis, Schley, Bradley, Van Deman;* for west Texas: *Kincaid, Colorado, Halbert, Sovereign (Texas Prolific), Burket,* and *San Saba;* northern Louisiana and Mississippi and southern Arkansas: *Success, Carman, Pabst, Moneymaker, Stuart, Van Deman,* and *Schley.* In the more northern parts of the country, none but varieties which originated there should be planted, because the southern varieties are not hardy enough. The best of these are *Busseron, Posey, Indiana, Niblack,* and *Major.*

Where grown. Commercial planting, which began in Louisiana, Mississippi, and Texas, has spread to the Atlantic Coast States as far north as Maryland, and to California and Oregon. In nature, the pecan is found on rich, sandy lowlands. Experience has proved that it will thrive on many soils if deep, fertile, well-drained, and free from drought. It fails on any sands, mucks, and peats and shallow soils underlaid by rock or hardpan. Flooding, if not excessive, does no harm.

Orchard management. Since seeds produce variable results, propagation in nurseries is mainly by annular and clip budding and whip and crown grafting. Special care is necessary in this work, because the buds and scions are slow to "take," and because there is considerable danger of injury by storms breaking off the young shoots. When the young trees have grown 2 years in the nursery, they may be transplanted to the orchard, preferably in the fall after the leaves have dropped. They should be set at least 60 feet apart, the space between trees being used for intercrops of peaches, Satsuma oranges, cotton-corn, and truck, for 10 or more years.

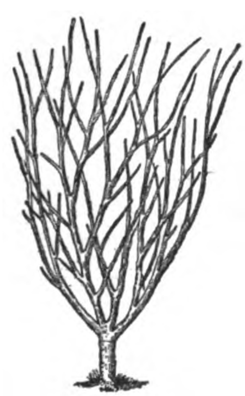


FIG. 415. Pear pruned to the vase form

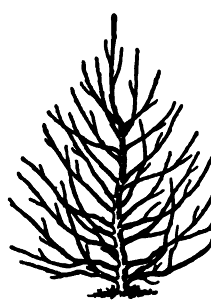


Fig. 416. Pear pruned to the pyramid form

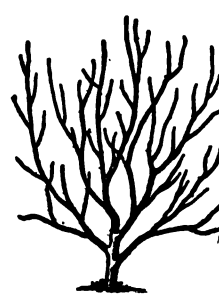


FIG. 417. Pear pruned to the natural form

FIG. 418. A pecan seedling tree topworked to an improved variety. (Farmers' Bulletin 700).

Clean cultivation, at least until the trees shade most of the ground, gives better results than allowing nature to have her way. Cover crops of hairy vetch, and clover or cowpeas sown after midsummer are beneficial.

When inter-crops are used, they should be fertilized well, but other dressings are rarely needed until the trees begin to bear; a little nitrogen may be added should the foliage look yellowish instead of a rich green by midsummer. When of bearing age, potash, and phosphoric acid fertilizers may be given as to other orchard crops. It is a bad practice to seed down the pecan orchard to grass, even where the soil is deep and rich; stunted growth and lessened production result.

Harvesting. For best quality, the nuts should ripen fully on the trees and drop naturally, though the late half of the crop may be beaten off with light poles. Care must be taken to prevent breaking the twigs and thus reducing the bearing area of following years. If threshed too early, the breakage will be great and the quality of the nuts inferior. Curing for 3 or 4 weeks is best done in a cool, dry place; a current of air and shallow layers—an inch or two deep—will hasten the process. Soiled nuts are usually washed before drying. Often they are polished by revolving them in drums or barrels. Dyeing is still sometimes done. These processes, while harmless in themselves, have so often been used to deceive purchasers into buying inferior nuts, that the demand nowadays is for untreated nuts, especially of named varieties.

Returns. Before 1890, practically all the nuts sold were wild. About that time, large, thin-shelled nuts brought prices ranging from 40 cents to $2.50 a pound, and thus stimulated commercial planting. While prices have fallen from these fictitious figures, there is a good demand for pecans at 30 to 50 cents a pound wholesale and 50 to 80 cents retail.

PERSIMMON. Several species of tree fruits, of which 2—the native or date plum and the Japanese or Kaki—are widely cultivated in America. The native persimmon grows wild as far north as St. Louis, and is cultivated to some extent even as far as Rhode Island and Lake Erie. In open ground, the tree is 20 to 30 feet tall; in rich river bottom forests, 80 to 100 feet. The almost globular fruit is ½ to 2 inches in diameter, sometimes seedless, very puckery while green and often when ripe, maturing from August to December. Contrary to popular belief, frost is not necessary to make it edible. Among the best varieties are *Boone, Smeech, Burrier, Shoto, Delmas, Ruby, Golden Gem, Early Bearing, Miller, Early Golden, Marion, Hicks, Kansas,* and *Josephine.*

The Japanese Persimmon or Kaki has been cultivated in America as far north as central Virginia, only since about 1876. While some varieties stand considerable frost, they are generally killed by zero weather. Though trees have succeeded in New Jersey and Long Island, the Kaki is a cotton-belt fruit. New varieties originating in America may extend the area northward.

The different varieties of this type ripen their fruits, which resemble ripe tomatoes, from August to November. Among the best are *Bennett, Zenge, Banfarik, Gemon (Among), Costata, Yeddo-Ichi, Fuyugaki, Tsuru, Gailey, Triumph, Hachiya, Taber No. 23, Hyakume, Tane-nashi, Nuyo-tan, Tamopan, Okame, Taber No. 129, Ormond (Boston Vining).*

How grown. While both groups of persimmons grow readily from seed planted as soon as ripe, budding and grafting of 2-or 3-year old stock are the only propagating methods that insure good fruit. The trees are harder to transplant than other fruit trees because loss of the tap-root is sure to result in death. Fall transplanting after the leaves have dropped has given best results. When replanted, the trees should be set 2 or 3 inches deeper than in the nursery. For the largest fruit, set the trees 20 feet apart each way, though very dwarf Kaki varieties may stand as close as 12 feet. As the roots go deep, crops may be grown between until the trees shade the space. Native varieties are easily cultivated, but the Japanese types often fail to bear through lack of pollination. The *Gailey,* "a constantly staminate variety," is recommended as a pollenizer at the rate of 1 tree to 7 of other kinds. A noted self-fertile variety is Tane-nashi. Except as indicated above, the trees are as easy to handle as any orchard fruits, thriving in any except wet soils and reponding to good treatment. Few

FIG. 419. Cluster of pecan nuts

FIG. 420. A persimmon entire and cut in half. Variety Tamopan

insects or diseases have been noticed upon them.

The fruits of the Kaki varieties are very variable, even those on the same tree. This is partly due to pollination, but is not fully understood. Persimmon trees may bear the second year after planting and, when 3 to 5 years old, yield several hundred good fruits. As with other orchard fruits, thinning improves size and quality.

PIGNUT, *see Hickory.*

PINEAPPLE. A tropical and semi-tropical American fruit grown commercially in southern Florida and other warm parts of the United States, and in other frostless countries. When allowed to ripen fully on the plant, it is one of the most delicious of all fruits, but for shipping it must be picked before quite mature. It is widely popular in the raw state, and for confections, preserves, and a flavoring.

Varieties. The most extensively grown variety is the *Red Spanish*, a fairly hardy, small-fruited plant. Varieties somewhat larger and of better quality are *Abachi* or *Abakka*, *Sugar Loaf*, *Enwille*, *Blood*, *Queen*, and *White Antigua*. Larger varieties of high quality are *Prince Albert*, *Black Jamaica*, and *Black Prince*. Among those of largest size and highest quality are *Porto Rico* and *Smooth Cayenne*. Several of these are known under other names; those given have been officially chosen by the Florida State Horticultural Society.

Where and how grown. Pineapples succeed in almost any dry soil. They will stand months of dryness, but moisture of either air or soil is unfavorable, even fatal. In Florida, sandy land too dry and poor for other crops is used. It is low in water content and lacking in plant food. In much of the area, the soil is only an inch or two above the soft, shelly rock. Liberal fertilizing is, therefore, essential to success.

Many of the choicer varieties are grown under "sheds" of slats to protect them from summer heat, and to check loss of warmth in winter; for pineapple leaves in open fields freeze at 32 degrees F. though the hearts may not be killed. Under sheds they have withstood 25 degrees F. without much damage. The sheds are high enough to allow a man to stand erect and seldom cost less than $500 an acre. When many new plants are desired, care is exercised to leave the "slips" immediately below the fruits. These will produce new plants but are a year slower than "suckers" which develop near the ground and make strong plants within a few months. From 2 to 5 suckers may develop by September on a strong plant from which the fruit has been gathered in June. Underground buds called *rattoons* are left in the field to replace the plants that have borne, but they are not numerous enough to make good all the losses, so sucker plants are used to fill in the blanks. Crowns are little used because they go to market with the "apples."

Planting. Varieties differ in their requirements. Small growers may be set 18 to 20 inches apart; largest sizes 30 to 36 inches, generally in checks and always in beds 6 or 8 rows wide. From 8,000 to 15,000 plants are set to the acre. These cost per 1,000 from $3 for Red Spanish, to $350 for the best kinds.

Cultivating and fertilizing may cost from $30 to $150 per acre. All work must be done by hand with a scuffle hoe to avoid breaking the brittle leaves. The workman stands in the path and avoids entering the bed from setting time until harvest. Only the surface inch of soil is stirred and this after the fertilizer has been applied. Favorite fertilizers are dried blood, nitrate of soda, and carbonate and sulphate of potash, and ground bone. At planting time, a small handful of cotton-seed meal is dropped in the bud. In October 400 pounds of low-grade sulphate of potash and 600 pounds of ground bone or its equivalent in other fertilizers are given. In February, a second dressing of 10 to 25 per cent more is given; a third in June; and the fourth in October. In each of these latter cases, the amounts are increased somewhat if the plants are growing well.

Harvesting is done about a week before the fruit matures. Great care is necessary to

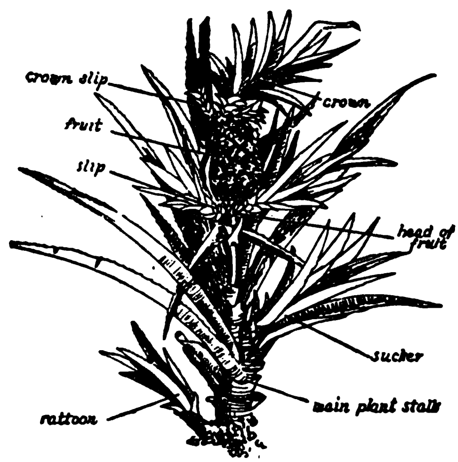


FIG. 421. Pineapple plant with parts named. (P. R. Bulletin 8)

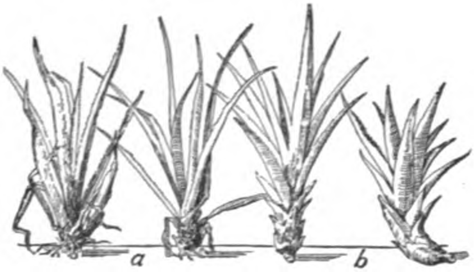


FIG. 422. Pineapple slips of good *b* and poor *a* type. (P. R. Bulletin 8)

prevent bruising. Each specimen is wrapped separately in brown paper and packed firmly in a crate or barrel—each size by itself—54 small ones up to 18 large ones to the half-barrel crate. In 18 months a new plantation may bear its first crop of 50 to 100 crates per acre. Mature plantations, well managed, may yield 300 to 500 crates or even more and continue profitable for 8 or 10 years. Usually the second, third, or fourth crop is the largest.

Returns from plantations depend largely upon the variety grown. Red Spanish and other common varieties grown mainly for fruit have sometimes yielded $400 gross, an acre. Choicer kinds have often more than doubled that amount, besides returning $500 to $1,000 for plants sold.

PISTACHIO-NUT, the seed of a plum-like fruit native to the Mediterranean region. The tree, which grows about 20 feet tall is cultivated to some extent in southern California and may also be grown in southern Florida and other warm localities between these two states. The nut is used mainly for flavoring and coloring confectionery, ice cream and other culinary preparations.

PITANGA, *see Cherry, Surinam.*

PLANTAIN a tropical fruit similar to the banana (p. 310) but harder and thicker. It is almost always cooked before being eaten. The name plantain is also applied to certain weeds common in temperate climates.

PLUM. One of the most widely grown of temperate-climate fruits ranking in America after the apple and the peach. Many species, most of them natives of America, are back of modern varieties, but the largest number of important sorts are of European origin, and the next largest are Japanese. As most of the 300 American varieties are inferior to the best European and Japanese varieties, the latter should be chosen for planting except where they fail and the Americans succeed, as in the Mississippi Valley, the cold North and the warm South. The really important commercial and dessert varieties grown in the eastern and the Pacific Coast states, belong (with a few Japanese exceptions) to the European group.

FIG. 423. A pineapple cut across showing flesh, and seeds.

Types and varieties. The European plums include: (1) Green Gages—small yellowish or greenish, globular, high quality as *Reine Claude, Pearl, Peters;* (2) Prunes—sweet varieties which can be dried as *Italian* and *German Prunes;* (3) Damsons—small, firm fruits suitable for cooking but not desserts, as *Shropshire* and *French;* (4) Large, colored, including reds, blues, and purples, mostly of inferior quality as *Bradshaw, Lombard, Quackenboss.* Among the Japanese sorts, *Burbank, Abundance,* and *Satsuma* are the leaders, though on the Pacific Coast, *Wickson,* and *Kelsey* are important. The *Wild Goose* and *Chicakasaw,* American plums, adapted to the Mississippi Valley from Michigan to the Gulf States, are little grown elsewhere. Other leading natives are *Wayland, Miner, Newman, Lone Star. Moreman, Wild Goose,*

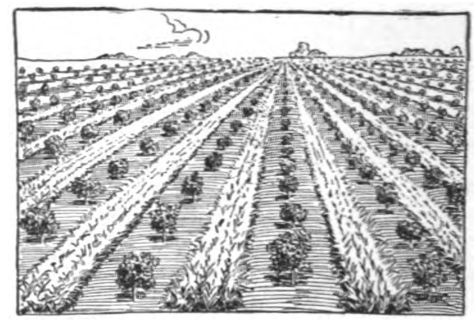


FIG. 424. Pineapple and orange grove, the former being grown in beds three or four plants wide. (P. R. Bulletin 8).

Golden Beauty, and *Caddo Chief.* The beach plum which grows wild from New Brunswick to the Carolinas has no important varieties but is worthy of culture for cooking purposes on sandy soils where other plums fail.

Where grown. While the European varieties may be set in blocks of a single kind, the Japanese do best when several are planted together. The natives apparently must also be planted in this way as many of them are considered self-sterile though the trouble may be due to other causes not yet understood. European varieties do best on heavy loams; Japanese on lighter soils, and American varieties on moist soils of moderate loaminess. The trees should be not older than 2 years from the bud when set, and 1 year in the case of Japanese and other strong-growing kinds. Favorable distances between trees are 20 feet each way, though some growers plant in rectangles 18 or 20 feet one way and 12 to

15 feet the other. At planting time, the trees are pruned like apple trees so as to be low-headed with 4 or 5 main branches, the lowest about 2 feet from the ground. Some growers cut out the leader and have their trees vase shaped, others leave the leader in and have the trees more or less pyramidal. One method is as good as the other.

Pruning. Later pruning depends somewhat upon the variety grown. As European varieties bear mostly upon spurs, care must be taken not to cut or break off too many. Japanese kinds bear partly on spurs and partly from buds in the angles of last year's leaves, so a little more cutting may be done if necessary, mainly to keep the bearing parts close to the trunk and main limbs. Rather than prune too heavily, especially the Japanese varieties, it is thought better to reduce the plant food in the soil, either by sowing cover crops that take up a good deal of nitrogen, or by witholding fertilizers, or both. Beyond observing these points, pruning consists in the removal of only such parts as are failing or are growing out of proportion to the rest of the tree. Many American varieties defy pruning to make them shapely or open. When headed back, they become impenetrable with twigs and thorns. About the only thing to be done is to thin out the branches just enough to allow pickers to get into the trees.

Cultivation. Plum orchards do best under tillage—spring plowing and frequent shallow cultivation till midsummer when a cover crop of crimson clover, or rye and hairy vetch is sown. Where the land has become rich in nitrogen by this practice, barley or oats are often used because they merely save the soluble plant food from being washed out of the soil and do not live over winter and produce a rank growth as rye does in the spring. Plum trees seem to need more water than do other fruit trees and thrive on moister land; grass and grain therefore should not be grown in the plum orchard. Inter-tilled crops are permissible until the trees reach bearing age. It is claimed that there is less brown rot in cultivated than in uncultivated orchards because the diseased fruits are buried.

Fertilizing. Commercial growers nowadays use far less fertilizer than formerly. They say that because the fruit is mostly water, because the roots go deeply and spread far, and because the trees utilize large quantities of water, much-diluted solutions of plant food will supply most of the needs of the trees. There is need of experiments to determine what quantities should be applied. Probably an average application to trees in full bearing is 500 pounds to the acre, the mixture carrying 5 to 6 per cent of nitrogen, 8 per cent of phosphoric acid and 3 to 4 per cent of potash. For younger trees only the area covered by the branches need be fertilized, so much less fertilizer will be required.

Yields. Plum trees begin to bear at 3 to 5 years from planting, the Japanese kinds somewhat earlier than the European and the American sorts still later. When 8 to 10 years old, the more productive large-fruited varieties of the first 2 groups should bear 3 bushels to the tree in a good year and perhaps none the next. Small-fruited kinds, especially the Damsons and American sorts, are more regular, yielding about 2 bushels annually.

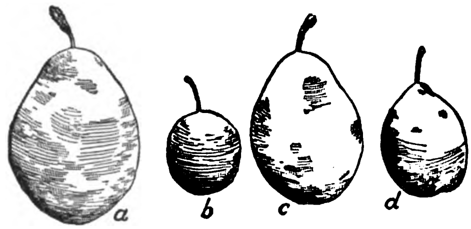


FIG. 425. Plum varieties, illustrating different types: *a* Pond; *b* French Damson; *c* Yellow Egg; *d* Italian Prune. (N. Y. Dept. of Agr. Bulletin 79.)

Harvesting. For nearby markets, the fruit is gathered just before reaching edible condition; for more distant ones, while somewhat greener. This is not only because it can be handled better, but because it is injured less by brown rot than when more mature. Japanese varieties are often picked a week or even two before ripe because they develop color and flavor better than do European kinds. Only ordinary care is observed in picking to avoid bruising.

Marketing. Six-, 8-, and 10-pound baskets are generally favored in the East as market packages; in the West, the individual fruits are largely wrapped in tissue paper and packed in boxes. Rarely are plums stored longer than a week in common storage and 3 to 4 weeks in cold storage, though late kinds, especially the prunes, may be kept even longer. The local market is generally the best place to sell plums because the losses due to long transit and middlemen's charges are eliminated.

PLUM, NATAL, *see Caraunda.*

POMEGRANATE. A small, south Asiatic, bushy tree grown in warm countries for its red, wax-like flowers, and round crimson fruits. From Maryland southward, and from Florida to California, as far north as San Francisco, it is somewhat popular in home gardens. A few commercial orchards are in the Gulf States. In habit of growth, the trees resemble the quince, and may be trained the same way, as either bushes or trees. The leathery-skinned fruits are filled with seeds each in a pink or crimson juicy pulp varying from almost tasteless to very acid. When sugared, the pulp is eaten alone or mixed with other fruits; it is also used in making cooling drinks. Among the best varieties for fruiting are *Acid, Paper Shell, Dwarf, Spanish Ruby* (or *Purple Seeded*), *Rhoda, Wonderful, Sweet,* and *Sub-acid.*

How grown. The plants are propagated from hard-wood or soft-wood cuttings (p. 329) or by layers (p. 321). Many shoots develop at the base of the tree which some say should be removed to strengthen the main bearing branches. These may be used for propagating as they often have root systems of their own.

FIG. 426. Two plum enemies: brown rot, and the curculio which makes the crescent-shaped wounds shown here.

Cultivation is as simple as that of currants, figs, or quinces. Any good, rich garden soil will serve. The trees begin to bear when 4 or 5 years old and continue indefinitely. The earliest varieties ripen in August; later ones in September. The fruit may be kept in good condition for several weeks without unusual care.

POMELO, *see Grapefruit.*

POND-APPLE, *see Annona.*

PRICKLY PEAR or TUNA. A West Indian and Mexican cactus often 12 feet tall, widely cultivated in warm countries for its reddish-purple pear-shaped or round, sweet edible fruits 1 to 2 inches in diameter. It is well known from Florida to southern California both wild and as a hedge and fruit plant. The Indian fig, a close relative with yellow fruits containing a reddish edible pulp, is similarly cultivated.

QUINCE. A fruit related to the apple and pear but used, in America, only for culinary purposes. Certain Persian varieties are said to be edible when raw; American kinds are not. Hence the quince, though a highly valued home orchard fruit, plays a minor part commercially. The leading varieties are *Orange* (*Apple*), and *Champion.* Others are *Meech, Rea, Bourgeat, Van Deman, Bentley,* and *Fuller.*

Soil and culture. Quince trees thrive best in rich, dry, warm, heavy loams. As they are shallow-rooted and slow-growing, the deeper and richer the soil the better. Damp and cold soils produce woody fruits. Contrary to popular opinion, the trees suffer from too much soil moisture. Cultivation is like that of dwarf pears, the tillage tools being run very shallow to avoid injuring the roots. Many growers plow toward the trees both to protect them and to insure drainage. Over cultivation, and too much nitrogen, either from leguminous cover crops or fertilizing, should be avoided since excessive wood growth favors the fire blight disease.

Potash and phosphoric acid may be applied without fear and with much benefit especially on light soils. Barnyard manure and other nitrogenous fertilizers must be used with great caution—only to stimulate growth when the trees are not making enough.

As the trees are of dwarf habit, rarely exceeding 12 feet, they may be set 15 or even 12 feet apart. When set too close, they grow tall and are more subject to blight than when given ample space. When planted preferably after 2 years' growth in the nursery, the trees may be pruned for a tree form as with apples or peaches, or allowed to develop as bushes with several stems. Where borers are not troublesome, one plan is as good as the other, but where they are abundant, the bush form is perhaps better because a constant supply of new stems may be produced as the injured ones are removed. Later pruning aims to keep the head open and spreading as with dwarf pears (p. 344). Care must be taken to leave plenty of uncut twigs for fruiting, because quinces bear their blossoms on the tips of young shoots developed from buds that pass the winter. As most of the buds that produce these growths are at the tips of last season's twigs, their removal would mean less or perhaps no fruit. Unless these growths are thinned out, however, the trees will become so full of end twigs that inferior or no fruit will result.

Yields. While the fruit seems hard, it is easily bruised and every bruise results in a brown spot; therefore, it should be handled carefully. In the general market $2.50 to $5.00 a barrel is the usual range in price. Well-handled, mature trees may bear 1 to 3 bushels of first-grade fruit annually. A fair average yield is 200 bushels an acre. Trees may begin to bear the third year after planting, becoming profitable when 8 to 12 years old and continuing so for 30 to 40 years.

FIG. 427. A prickly pear plant, the arrows showing where the flowers and fruits develop on the fleshy leaves, or rather flattened stems.

RASPBERRY. A bramble of which the fruit separates from the receptacle when ripe (Compare blackberry, p. 313). European varieties were found to be unsuited to this country so those now commercially important belong to 2 native species which, directly or by hybridization, have given rise to red, purple, yellow and black varieties.

Varieties. The *Cuthbert* is the most important red variety, and probably the *Gregg* leads among the blacks. But there are countless others among which the following are important: Red: *Herbert, Marlboro, Ruby, St. Regis, Louden, Miller's Red, Brilliant, King.* Purple: *Columbian, Shaffer, Royal Purple.* Yellow: *Golden Queen.* Black: *Cumberland, Kansas, Palmer, Plum Farmer, Black Diamond, Eureka, Ohio, Souhegan, Mammoth Cluster.*

Yields vary widely with soil, season, care, age of plantation and many other factors. Usually nothing can be expected the first season except that some "everbearing" kinds may produce a few fruits in the autumn if the plants are set early in spring and given exceptionally good care. The second year a partial but generally not profitable yield will be made. The third season after planting, a good yield would be 3,000 quarts per acre or perhaps more. Yields of 6,000 to 10,000 quarts to the acre are fairly common.

Soils and Fertilizers. Raspberries, like blackberries, dewberries, and Loganberries succeed best in deep, moist but well-drained loams. It is essential that the soil withstand drought well; hence subsoiling is often an advantage. Abundant vegetable matter is also helpful. Leguminous cover crops will supply it after the plantation has been started. They will also supply all the nitrogen needed.

FIG. 428. The quince is an old-fashioned and rather unappreciated fruit

Stable manure is not desirable for red raspberries on moist, rich soils, because it develops too much wood which tends to winter-kill. Ground bone, floats, and basic slag for phosphoric acid, and wood ashes or muriate of potash for potash, will give best results if applied to the cover crop. Should excessive growth of the plants occur, it should be checked by growing rye, buckwheat or rape for a year or so to use up the excess nitrogen in the soil.

FIG. 429. Quince tree showing the tendency to develop shoots beyond the bearing branches.

How grown. Planting should preferably be done in spring. The plants should be taken from comparatively young patches because these are more vigorous and freer from disease than old ones. Red raspberries and blackberries produce new plants from suckers and root cuttings; blackcaps and dewberries from the tips of the canes which take root. Some varieties will reproduce in both ways. Distances for planting vary with the varieties. Red, purple, and yellow raspberries are usually planted 2 to 3 feet apart in the rows with the rows 5 to 8 feet apart. Often they are allowed to form a continuous hedge with 2 to 4 or 5 canes to the running foot. Blackcaps, because they can be kept in hills, are often set in checks 5 by 5 to 8 feet, otherwise 4 by 6, 5 by 7, or 6 by 8 feet. During the first year, potatoes, cabbages, or beets are often grown to offset the cost of tillage.

Cultivation continues from early spring till midsummer when a cover crop is sown, or the plantation may be mulched with straw till after harvest. This latter plan, however, tends to make the plants shallow-rooted and thus lessens the chance of good yields in dry seasons. Cover crops should be disked rather than plowed under. Square-pointed cultivators are recommended for cutting suckers of red raspberries and blackberries.

Tender varieties may be protected in winter by covering them in late autumn with earth, the tops being held down with a fork until covered. Preferably the tops should lie in the direction of the row so that the crowns will be well covered.

When the shoots of the blackcaps are 18 to 24 inches tall, the terminal bud should be pinched out; this will make the stem stiff,

FIG. 430. Clusters of blackberries *a* and raspberries *b* showing the difference in the way they part from the stem (see text).

self-supporting and branchy. In the spring the side branches may be shortened to 15 to 24 inches depending upon the position of the fruit buds which differs in different varieties. Puny shoots should be destroyed so all plant food will go to fruit formation. As soon as the fruit has been gathered, the fruited canes should be cut and burned immediately. They will die anyway, and will spread pests as long as they remain standing, besides cutting off light and air. Enemies are about the same as those of the blackberry (p. 313).

Fruit should never be picked when wet, never before it is fully ripe, never be allowed to stand in the sun, and never be placed in deep or large boxes. Pint boxes are large enough for raspberries; quarts for blackberries and dewberries. Wet berries spoil; sunned ones fade and lose flavor; unripe, poorly-flavored ones give the grower a bad name. Because the fruit, especially of the black varieties, may be easily dried, the raspberry may prove profitable in localities from which it could not be shipped in the fresh state. The United States Department of Agriculture issues Farmers' Bulletins that contain much valuable information on evaporating.

SAPODILLA, NASEBERRY, a West Indian evergreen tree hardy as far north as Lake Worth, Florida, and more or less in cultivation westward to southern California for its pear-flavored, intensely sweet fruits which resemble small russet apples in size and color. In tropical and subtropical countries the fruit is highly valued both as a fruit and as a source of chewing gum.

SAPOTA. A Mexican evergreen tree cultivated in warm climates for its edible, plum-like, greenish-yellow fruits with a flavor suggesting the peach. Specimen trees at Santa Barbara, California, are said to be about 100 years old and to have borne fruit annually in spite of neglect. Probably the tree would thrive in the warmest parts of Louisiana, Texas and Florida, and perhaps even farther north since it grows well from the coast of Mexico up to altitudes of 7,000 feet. It may be easily grown from seeds.

SERVICE-BERRY, *see Juneberry.*
SHAD BUSH, *see Juneberry.*
SHADDOCK, *see Grapefruit.*
SHAGBARK, SHELLBARK, *see Hickory.*
SONCOYA, *see Annona.*
SOUR-SOP, *see Annona.*
SPANISH PLUM, *see Jew Plum.*
SPARKLEBERRY, *see Farkleberry.*

STAR-APPLE. A West Indian tree about 30 feet high with milky juice, widely cultivated in frostless climates for its smooth, globular, white or purple fruits which, if allowed to ripen, are highly valued as a dessert. As it is very tender it can be cultivated only in the frostless parts of Florida, Louisiana and westward to California. It propagates readily from seeds, and thrives on any well-drained, moderately rich loam.

STRAWBERRY. A low-growing, herbaceous perennial grown more widely throughout America than any other fruit. Plants will bear for 5 or 6 years, but after the second, the fruit is usually inferior. Partly for this reason, and partly to get rid of weeds, insects and disease, strawberry beds are generally plowed up after producing one good crop, either the first or the second year after setting.

Varieties. No fruit crop varies so greatly or so quickly as the strawberry; the popular varieties of the 'nineties are almost unknown. Therefore new ones should be tested in lots of 25 to 100 plants before being planted largely. Another point is that many kinds are pistillate or "female" and must have staminate or "perfect" plants near by, or the quantity of fruit will be small and perhaps largely inferior. All nurserymen's catalogues indicate which varieties are pistillate and which ones "perfect." One row of the latter to 2 or 3 of the former is a safe proportion. Popular, extra-early kinds are *Early Ozark, Excelsior, Michel's Early*; second early: *Clyde, Crescent, Klondyke, Senator Dunlap;* mid-season, *Bubach, Glen Mary, Haverland, Marshall, Warfield, Wilson Albany*; late, *Aroma, Brandywine, Chesapeake, Fendall, McAlpin, Nick Ohmer, Sample, Sharpless, William Belt*; very late, *Gandy, Pearl, Steven's Late Champion* and *Kellogg's Prize.*

Certain so-called "everbearing" varieties will bear in the autumn as well as the summer. They are handled like the others except that better results can be secured by destroying all the flowers that appear in the early part of the season. On Long Island, New York, and in similar climates, ripe berries may be gathered as late as Thanksgiving Day. *Progressive, Superb, Americus* and *Peerless* are leading varieties of this class.

Soil and Preparation. Strawberries do well on almost any fairly moist soil that will grow a good crop of potatoes or corn, but they will often succeed where corn fails because of cold nights and short seasons. Rich land and liberal manuring are factors in growing the

best crops, and good drainage is imperative. Best results are secured on moist, dark, sandy loams that can be fertilized and built up by manuring and tillage. A naturally poor but warm early soil is generally better than a heavy one, especially if the latter be wet.

When available, 20 to 30 tons per acre of well-rotted stable manure should be applied to ordinary land, either before plowing or afterward, when it must be disked in. The next best fertilizer is probably a mixture of finely-ground bone meal (200 to 700 or more pounds per acre); or acid phosphate (400 to 500 pounds); nitrate of soda (100 to 200 pounds); and muriate of potash (50 to 100 pounds). Apply this after plowing but before planting, or save out the nitrate and apply 50 to 75 pounds at a time as a top-dressing during the growing season. Give a surface dressing of the mixture the spring after planting, but don't get any on the foliage.

Whenever possible, the area to be planted should have been under cultivation 2 or more years, preferably in potatoes, beans or corn, to get rid of white grubs, wire-worms and cut-worms which live in sod and which, perhaps more than any other cause, are responsible for failures of newly-set beds. Hence newly-turned sod, especially if old, should never be used for strawberries. Plowing should always be deep and thorough enough to turn all trash beyond the reach of harrow teeth.

Propagating. The plants reproduce themselves true to variety by means of runners developed usually after the fruit has been gathered. These normally bear the following summer, though in fall-bearing kinds they may produce some fruit the same season. The best runners for setting are those with small crowns of rather few leaves but with an abundance of fibrous, light-colored roots; dark roots indicate older plants. To secure good plants, many growers choose only the first plants produced—the ones nearest the parent plant—avoiding those developed later and farther away. Provided the latter have made good roots and tops, and are healthy, there is really no noticeable difference.

Planting. After fine harrowing and smoothing, the rows may be marked out about 30 inches apart. Before setting, each plant should be trimmed of dead and excess leaves, and have its roots shortened to about 4 inches. The easiest way to trim the roots is to take a handful holding the crowns in the thumb and forefinger and letting the roots lie across the palm; then with one snip of the shears, cut off all roots that extend below the little finger. Trimming pays in both speed of setting and after-development. Best results in setting usually follow the flat-trowel method. In this the trimmed plant is held by one hand so the crown is neither above nor below the soil surface in the hole just made;

FIG. 431. Strawberry blossoms: 1 and 2 are perfect, that is with both stamens and pistils; 3 is imperfect, having only pistils. (Farmers' Bulletin 198.)

the trowel is again thrust in the ground and the soil pushed over and firmed thoroughly against the roots from bottom to top. If set with the crown too high, the roots will dry; if too low, the crown will rot; in either case, the plant will die. Expert planters give each plant a whirl between the fingers and thumb to spread the roots before placing it in the hole.

Distances between plants in the rows vary from 12 to 36 inches according to variety or system followed. In the "hill" system, where the plants, set in "checks," form clumps but are not allowed to form runners, the greatest distances are used so cross-cultivation may be given; in the matted-row method where practically all the runners are allowed to grow until the rows almost touch, the smallest distance is fairly popular, though 15 to 18 inches is more common. The latter is popular also in the "hedge-row" method, in which enough runners are allowed to grow to form a dense row 12 to 18 inches wide.

In humid climates, the time for planting depends more upon rainfall than upon any other condition. In general, early spring is the favorite season; but with pot-grown and other well-rooted plants and moist soil, late August and early September often give good results. Spring-set plants do not produce a crop until the following year, whereas those set in early fall often give a partial yield the next summer and an excellent one a year later. Where the seasons are long, as in the southern states, planting is usually done in June, runners of the same season being used. Where irrigation is practised, planting may be done whenever other conditions are favorable.

Cultivation. With no other fruit crop is clean cultivation of such importance. Weeds, especially creepers like chick-weed and purslane ("pusley"), must be kept out, and moisture must be saved because the strawberry feeds close to the surface. Frequent, shallow tillage is, therefore, essential until the plants have full possession of the ground, after which it may often be necessary to hoe or hand-pull some weeds. A better stand of plants may be maintained through dry weather by good tillage than in any other way. Except in the hill system, cultivation must stop when

FIG. 432. A well-grown strawberry plant. The roots should be cut back about one-half in transplanting. (Farmers' Bulletin 198.)

the plants occupy the ground, so the more thorough it is in the early part of the season, the better.

Mulching. Some growers mulch their beds during the first season, but this is not usual; cultivation to maintain a "dust mulch" is preferred. All growers, at least in frosty sections, agree in favor of winter mulching. The object is less to protect the plants from freezing than from alternate thawing and freezing which settles and heaves the ground and breaks the roots. The best mulch is salt or marsh hay because any weed seeds it may contain are water-loving plants that fail on dry ground. Other good ones are pine-needles, clean straw, buckwheat stems and corn stalks if not very coarse. The proper time to apply a winter mulch is as soon as the ground is frozen.

In spring, when grass begins to grow, the mulch must be raked off the plants to the space between the rows where it may be left until after harvest to serve both as a mulch and as a partial protection against rains that would splash mud on the berries. In cold regions, instead of a late autumn application, heavy mulches are often placed on the beds during midwinter after a heavy fall of snow. The object is to keep the ground frozen as late as possible in spring. In any case care must be taken to remove the mulch as soon as any of the plants show whitening of the leaves or stalks, otherwise damage to the plants and injury to the crop will follow. By the last mentioned, growth, blossoming and even fruiting may be delayed 3 to 15 days or sometimes even more. In localities where the ground freezes little if any, mulches prevent undue drying during fall and winter. For this purpose, they are applied in late November or early December and allowed to lie between the rows until after harvest.

Late sowing of barley, oats, buckwheat or other grain between the rows is practised to a limited extent. The chief objection to it is that these crops take too much moisture.

Renewal of fruited beds. Many growers fruit their beds for 2 to 5 years by various methods of renewal. One popular plan is to run a mower over the rows as soon as picking is over, cutting the plants close to the ground. In a day or two of sunny and breezy weather, hay tedders or hand forks are used to toss up the mulch which, as soon as dry, is lighted on the windward side of the patch and burned off quickly. In a couple of weeks, new growths appear and a fine looking bed results. Usually the spaces between rows are plowed to break up the packed soil. The chief advantage of this method is the destruction of countless weeds, bugs and diseases.

Another plan is to allow the new runner plants that form after harvest to take root in the freshly-plowed and harrowed spaces between the rows, and a few weeks later, to plow and harrow the original rows. Good results are often secured by this plan, which demands comparatively little work. Disadvantages of all renewal methods are that the ground does not get thorough enough preparation or cultivation, the plant food in the soil becomes more depleted each year, and both quality and yield of fruit deteriorate, unless special care is given to fertilization. Leading growers treat the strawberry as one crop in a regular rotation.

Rotation Systems. These are of 4 classes: (1) In the annual plan, popular in the South, the plants set about midsummer grow practically all winter, bear the following spring, and after supplying plants for a new bed, are plowed under. The crop, therefore, fits like wheat or potatoes in any rotation scheme of annual and perennial crops. (2) Often the field is cultivated through the season succeeding its first cropping, and the following spring allowed to bear again, after which a new field is planted and the old one plowed. Thus the crop becomes a biennial like hay in the rotation. A modification of this plan is to plant in November or even February, secure a partial crop the following spring and a big one a year later. In this plan, a new field is set every year and an old one plowed, the idea being to have new beds constantly replacing old ones. (3) in the triennial plan, the field may or may not bear the first season depending upon when it was planted, but 2 large crops are secured before plowing. (4) in the perennial plan, 3 or even more crops may be harvested. Northern growers rarely follow the last 2 practices,

FIG. 433. Field of strawberries grown by the hill system. (Farmers' Bulletin 198.)

usually cropping their fields only once or twice. In both northern and southern practice, other crops are alternated with strawberries. A popular plan is wheat followed by timothy, clover and hay for 1 to 3 years, then potatoes or corn followed the same season by a cover crop of crimson clover or rye and vetch plowed under in spring for strawberries.

Harvesting. For fancy markets the fruit stems are often nipped rather long, the large specimens placed as gathered in boxes by themselves. As the fruit is very tender it must be handled very carefully. Pickers are often required to do the sorting as they pick. Boxes are often "faced" so as to show an almost unbroken red surface. While this takes a little time, it pays well; graded and faced fruit often commands 2 to 3 times the average price for ungraded stuff the same day. As with other fruits, the stage of ripeness for picking depends largely upon the distance from market and the use to which the fruit is to be put. The universal market package is the "quart" box made in various styles and shipped in 24-, 32-, and 48-quart crates. Enormous quantities of strawberries unsuitable for market are annually canned, or made into "juice" for soda fountains.

Yields and profits vary greatly. Good yields are 3,000 to 8,000 quarts to the acre; excellent ones 8,000 to 12,000; maximum 12,000 to 15,000. Prices range from 3 cents gross or less a quart in seasons of glut, to 20 or 25 cents for extra early or extra fancy fruit in the best markets. The cost of producing an 8,000-quart crop is between $300 and $400 an acre or about 5 cents a quart.

STRAWBERRY TREE. A small, south European tree much planted in parks and gardens for its bright green foliage, white or red flowers and scarlet, warty, strawberry-like fruits which ripen as the blossoms for the following crop open. These are used raw or cooked. While the tree is not hardy in cold localities, it is highly valued in home plantations in California and should be popular in many parts of southern United States.

FIG. 434. Field of strawberries grown on the matted-row plan. (Farmers' Bulletin 198)

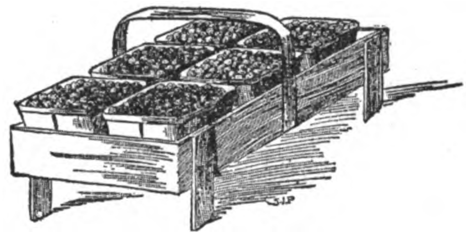


FIG. 435. A handy basket carrier for strawberry picking

ST. JOHN'S BREAD, *see Carob.*

SUGAR-APPLE, *see Annona.*

SWEET-SOP, *see Annona.*

TAMARIND. An evergreen, tropical tree probably a native of India or Africa. It resembles our common locust in growth, foliage and fruit but is more beautiful and often much larger. While useful for ornament and timber, it is most grown for its pods which contain a pleasingly acid pulp that separates readily from the husks and may be easily sun dried. It is used either raw or prepared in various ways, especially as a cooling drink. The pods imported from the West Indies are often obtainable at fancy fruit stores in the principal northern cities. Trees are easily raised from cuttings and seeds but are slow growing. They have done well in southern Florida and westward in warm localities to southern California. For roadside trees and for home grounds they should be more fully appreciated.

TI-ES, *see Marmalade tree.*

TORETA, *see Annona.*

TREE TOMATO, *see Cyphomandra.*

TUNA, *see Prickly Pear.*

WALNUT. Various trees of the botanical genus *Juglans*, the leading one of which is the Persian or so-called English walnut (*Juglans regia*) a native of western Asia, but cultivated commercially not only there but in countries bordering the Mediterranean Sea and also more recently, in the Pacific Coast states. The next most important species is the American black walnut (*Juglans Nigra*) which is native from New England to Minnesota and southward to Florida and Texas. The third species, a native of Eastern Asia, is the Japanese walnut (*Juglans Sieboldiana*) which has been introduced into America as an ornamental and for its butternut-like nuts.

The Persian walnut industry. While the Persian walnut is grown somewhat in many states the principal orchards are in California, where about 50,000 acres are devoted to it. This means about a million and a quarter trees which yield from 12,000 to 15,000 tons annually valued at about $290 a ton or between $3,500,000 and $4,350,000. The investment in orchards, apparatus, storage

warehouses, etc., in California is estimated at considerably more than $40,000,000.

Walnut growing, although not reputed as profitable as the culture of the leading citrus fruits, is one of the most satisfactory, staple and permanent of orchard investments. While yields and incomes vary considerably with climatic and soil conditions, the variety grown and the methods of management, from $100 to $300 an acre may be considered the general range for net returns. Orchards of ordinary varieties as commonly managed will annually yield 800 to 1,000 pounds of nuts per acre while better varieties, better managed, will give from 1,500 to 2,000 pounds.

One of the most satisfactory features of walnut orcharding is the non-perishable nature of the product which, when properly cured, may be held in storage for a year or more if necessary. Another assuring feature is that, while importations of Persian walnuts from the Old World have steadily increased during the past decade or more, during the very period when California orchards have been increasing their output, yet the prices paid to California growers have not been reduced but have even increased. The probable reason is that walnuts are entering more and more liberally as a staple food into the diet of the nation as well as maintaining their former prominent position for use in confections and other manufactured edibles. Hence walnut growing seems little threatened with over-development.

FIG. 436. Typical leaves and nuts of the Persian (*left*) and native black walnut (*right*). (Ore. Bulletin 92.)

During the past 2 or 3 decades the Persian walnut has been attracting attention from southern Connecticut to Missouri and southward as a possible orchard tree, because during the past 40 years or more occasional and widely scattered seedling trees have been known to thrive as far north as western New York and adjacent Ontario. Small orchard plantings have been made in various parts of the area outlined and though the trees are still young many of them have yielded profitable crops. So far only a few of these hardy walnuts have been named and offered for sale as grafted or budded nursery trees. The buyer, therefore, runs practically the same risk in buying unnamed, ungrafted or unbudded seedlings as he would in buying seedling apples or peaches—he may and probably will be disappointed by getting worthless, tender, unproductive and otherwise inferior trees.

Types and propagation. With the exception of less than half a dozen named varieties (of which the Thomas is the only one of prominence) the American black walnut is propagated by seeds. Seeds of the other species are used to produce trees among which may occur a few worthy of being named and increased by budding and grafting so that their characters and quality may be maintained. As the species readily hybridize, it is probable that many new kinds will be thus originated.

Budding and grafting have now replaced the earlier seedling method in commercial orchards. The leading commercial varieties in California are Placentia and Eureka, which comprise about 75 per cent of the trees; Franquette, El Monte, and Prolific are perhaps the 3 next most important. All these are usually crown grafted on seedlings of the northern California walnut (*Juglans Hindsii*) because of its ability to withstand unfavorable soil conditions better than Persian varieties on their own roots. Several other stocks are being used more or less—Royal and Paradox hybrids especially—but, though they make good trees, they are less easy to get.

The seedling stock is generally grown one year in the nursery row and whip-grafted at the crown, just before growth starts the following spring. Best results seem to follow when a short whip-graft is tied in place with raffia or soft cotton twine, the completed graft covered with warm grafting wax and finally buried with soil or otherwise protected to prevent drying out before growth begins. As the sprouts grow they must be staked to prevent breakage.

Walnut culture. The Persian walnut delights in a deep, rich, alluvial loam abundantly supplied with humus and well-drained to a depth of at least 6 feet. On sandy loams and shallow soils where standing water is 5 feet or less below the surface, and in shallow soils underlaid by hardpan or rock, it makes unsatisfactory growth and soon dies. The foggy climate near the coast where the daily range of temperature is comparatively small, favors the tree, whereas inland where the air is dryer and the daily range of temperature greater, both trees and nuts are subject to sun-scald,

FIG. 437. Simple but adequate shed for sorting and packing perishable fruits, like strawberries, in the field

though among the newer varieties are some that promise better resistance to this trouble.

Formerly walnut trees were planted 40 to 50 feet apart in orchards, but these distances have proved too close and 60 feet or more are now preferred, especially where the soil is rich. In closely-set groves the trees except on the outside bear rather more lightly. One-year trees 6 to 10 feet tall are preferred for planting. These are generally pruned back to about 5 feet, though cutting back to 18 inches or even less is popular in some sections. In the latter case, only one sprout is allowed to grow until it reaches a height of 5 feet, when its tip is pinched. Such trees, though they must be staked, often produce as much growth as if left tall at planting time and only sparingly pruned. About the only pruning needed after the frame limbs have been selected, is the occasional removal of such branches as interfere with tillage, though some growers practise annual thinning of the branches. Trees so pruned generally bear a larger proportion of their crops near their centres and upon the main branches.

Orchard management consists of clean culture from March or early April until shortly before harvest in late September or October, after which a winter cover crop of sweet clover, rye or vetch is sown. By plowing time (in March) this crop is usually hip high or higher. Companion cropping in bearing groves is not common; in young ones hoed crops, vegetables, small fruits, alfalfa, peaches and apricots are fairly popular, but the trees mentioned tend to dwarf the walnut trees.

In California and other western states, irrigation is essential both to the production and the natural husking of the nuts. The furrow system of irrigation is popularly practised, from 1 to 5 or 6 applications being made during the growing season, each one being sufficient to saturate the soil to the depth of 6 or 8 feet so as to reach all the feeding roots. The last irrigation should be given within 2 weeks of harvest because it stimulates the shucks to open without falling from the trees, thus allowing the nuts to drop. If they cling to the nuts, the labor and expense of harvesting are increased.

The nuts fall naturally or are shaken off, gathered, washed, dried, culled, sacked on the farm and then delivered at a central packing house where they are bleached in brine or a mixture of chloride of lime, sal soda and sulphuric acid to remove discolorations and give the shells a handsome tan color. They are then dried or "cured," usually in currents of warm air or in lath bins. When thoroughly dry, they are graded, sacked and sold.

Insects and diseases include the walnut aphis which is controlled by tobacco extract sprays, and blight or bacterosis for which no remedy is as yet known.

WHORTLEBERRY, *see Blueberry.*

WINEBERRY. A Japanese, raspberry-like plant with small, soft, red, acid or insipid fruits. It is tender and generally inferior to both raspberries and blackberries.

FIG. 438. The generous bounty of the well-planned, well-cared for vegetable garden (see next chapter)

CHAPTER 28

How to Grow Vegetables

By PROFESSOR M. G. KAINS *(see Chapter 21). Edited by* LEONARD BARRON, *Editor of "The Garden Magazine." Chapters* 21, 22 *and* 23 *explain the* 3 *systems under which vegetable crops are grown, and the conditions needed for the success of those systems. The following information and directions consider the plants discussed mainly as material for the home vegetable garden and intensive, small-scale cultivation. In some cases they fall naturally together in groups, the culture of all in a group being about the same. Thus there come first the Cabbage Group (p. 361), the Herbs (p. 366), the Root Crops (p. 370), the Salad Crops (p. 373), and the Vine Crops, (p. 376). Following these group discussions, the remaining unrelated or unlike plants are treated alphabetically under the head of Miscellaneous Vegetables (p. 377). Any particular crop whether or not a member of a group may be at once located by means of the accompanying index. Enemies are not mentioned in this chapter; they, and all control and preventive measures are treated fully in Chapters* 32, 33, *and* 34.—EDITOR.

Index of Vegetables

The Cabbage Group

CABBAGE and allied plants form a large and most important group of vegetables. They are hardy, gross feeders requiring, generally, a cool season, rich, deep soil, and ample moisture. They must be kept growing vigorously by frequent tillage, or their edible parts will be stringy or strong, or fail entirely. All have been developed in cultivation from the perennial wild cabbage of Europe. Some men wanted loose leaves for use as greens, so developed varieties of collards and kales (or borecoles); others wanted thickened stems resembling turnips but developed above ground, so secured the Kohlrabis; another group wanted many small buds produced in the axils of the leaves, thus working toward Brussels sprouts; another group wanted the leaves all in one more or less solid head, so produced the cabbages; the condensed and thickened flower stalk appealed to others who gave us cauliflower and broccoli. Thus we have seven distinct kinds of vegetables developed from the original wild plant.

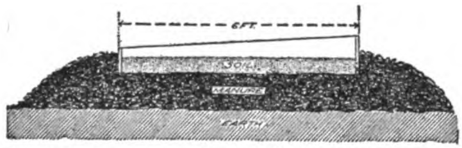


FIG. 439. Temporary hotbed in which manure is banked up around the wooden frame

Culture. While differing widely in form, the general culture of all is much alike. Seed may be (1) started in fall in cold frames, and the plants wintered over with ordinary protection; (2) sown in January or February in greenhouse or hotbed, hardened off in coldframes, and transplanted in early spring to the garden; (3) sown out-of-doors in early spring for later transplanting; or (4) in early midsummer for late crop. In the South, where winter protection is not necessary, fall and early winter sowing are popular. While an ounce contains about 8,000 seeds, only half this number of plants may be secured as a maximum, often only a quarter. In all cases, the young plants should be stocky from being kept cool and given ample space between them. Transplanting favors stockiness. When transplanting to the garden, the stems should be buried as deeply as the first leaves, especially when this work is done in hot weather; for the roots then have a better chance to get moisture than if transplanted shallow.

The soil can scarcely be too rich for these crops. A clover sod dressed with 40 to 60 tons of well-rotted manure to the acre, fall-plowed and left rough during winter, harrowed in early spring, and dressed with commercial fertilizer containing 300 pounds nitrate of soda, 700 of cottonseed meal, 750 acid phosphate and 200 muriate of potash, applied at the rate of 500 pounds an acre just before the plants are set, should pay well in quality and yield. Early crops do best in soils that warm quickly in spring. Sandy loams are best, especially if sloping east or south so as to "catch the sun." For later crops, heavier soils sloping west or north are better. The former should be deeply tilled in the fall, and surface-handled in spring; all tillage of heavy soils may be left till spring. The late crops may be preceded by some early crop such as spinach, garden peas, onion sets or lettuce, or planted in alternate rows of early beets, carrots or turnips.

Successful gardeners say these crops should be hoed daily, which means that cultivation can scarcely be overdone, but only the surface inch or two should be stirred. This will hold the moisture and thus favor steady growth and high quality. Tillage should start as soon as the plants are set out; twice a week is not too often, until there is danger of breaking the leaves.

BRUSSELS SPROUTS. Though the stem and the leaves resemble those of cabbage, Brussels sprouts does not form a cabbage-like head but many little heads or enlarged buds each in the angle where a leaf joins the stem. The first "sprouts" develop near the ground, the last near the top of the stem. They

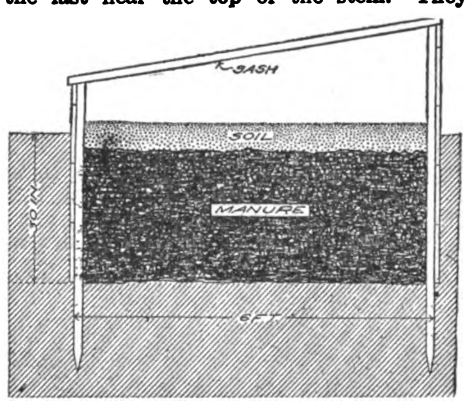


FIG. 440. Permanent hotbed with board sides. Some such equipment is required in producing early plants, both vegetables and flowers.

should be cut off with a sharp knife, not pulled. Development is favored by the removal of the leaves when the buds at their

FIG. 441. Brussels sprouts could and should be grown in more gardens

bases are formed. The plant is so hardy that from Long Island southward the crop is harvested between mid October and late March. In colder regions, for a home supply, the mature plants may be transplanted to moist loam in a cool cellar before winter sets in. About 2 weeks longer is needed to grow them, than for the slowest of late cabbage varieties. On Long Island, the seed is sown about June 10. Management is the same as for cabbage. The plants usually are set 30 by 36 inches. In America, dwarf varieties are popular; in Europe, tall ones. Brussels sprouts are considered the most delicate flavored of the "leaf" forms of the cabbage group.

CABBAGE. The most widely grown and valued of this group has many distinct varieties. The heads are conical, globular or flattened; the color is green or purple ("red"); the leaves are smooth or "Savoyed" (much wrinkled and deeply pitted). The Savoys are the finest in quality; the flattened and round-headed ones poorest, but the most popular for making sauerkraut. The "red" varieties are little grown (mostly for pickling) although some people use them boiled and spiced as a "green" vegetable. Some cabbages reach edible size in about 100 days from sowing the seed, and occupy only a square foot; others require more than double the time and 3 times the space. More than 500 names have been used by seedsmen, but all varieties may be placed in 7 groups of which the following varieties are typical: (1) *Etampes, Early York*; (2) *Winningstadt, Early Jersey*; (3) *Early Summer, Enkhuizen Glory*; (4) *Drumhead, Hollander*; (5) *Savoy*; (6) *Red*; (7) *Tronchouda, Portuguese Sea-Kale*. The varieties of each of these groups have special value in certain places, but this can be determined only by growing them.

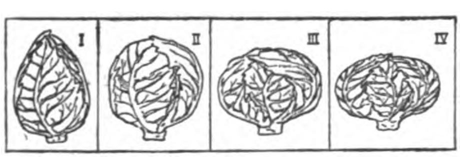


FIG. 442. Four types of cabbage based on shape: I, conical; II, round; III, flat; IV, drumhead

Culture. Cabbage does best in a moist, cool climate or season, and poorest in a dry, hot one or where hot, dry winds occur. Corn and tomato weather is unfavorable even when there is ample moisture in the soil, especially during the period when the head is beginning to form—loose, inferior or even no heads result. If exposed to long periods of cold, flower stalks instead of heads may form. While a Temperate Zone plant, few garden vegetables enjoy the sun more and shade less; therefore open spaces are best for it. If well supplied with water, it will thrive on less plant food than when water is lacking, but it will not tolerate excess of water.

For the home garden, two sowings of early seed may be made; one indoors during mid-

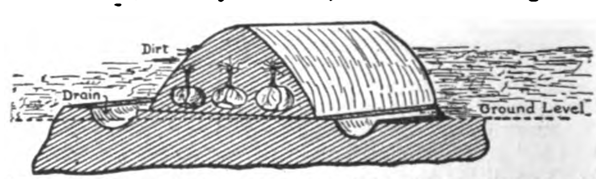


FIG. 443. One way to store cabbages outdoors. Straw or litter should be added as cold weather demands

winter, the other out-of-doors as soon as the ground can be worked. The late crop may be started shortly before midsummer. In each case, it is advisable to transplant the seedlings when they have formed their second leaves. If placed in flats, they may be spaced 1 or 2 inches apart for early removal to the garden; or double these distances if for later transplanting. Small-growing early kinds may be set 12 to 18 inches apart; large late ones 30 to 42 inches depending also upon the character of the soil. Cloudy weather during transplanting and a shower following favor a good stand.

Harvesting and storing. The time of har-

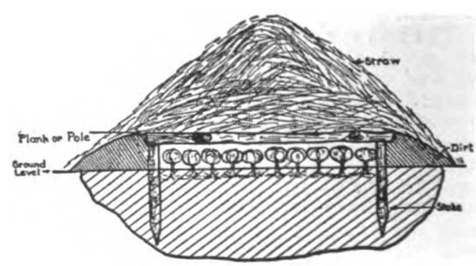


FIG. 444. Cabbages stored in a pit are more easily obtained for use during winter

Farm families would be better off—in health, in prosperity and in satisfaction—if more of them made such a collection as this a feature of their daily diet

And they could do so by maintaining well-planned, well-cared-for vegetable gardens

EVERY FARM SHOULD HAVE ITS GARDEN, IN WHICH ALL THE FAMILY CAN WORK, AND BY WHICH ALL CAN BENEFIT

THE FARM HOME HAS NOT FULFILLED ITS PURPOSE UNTIL IT IS BEAUTIFUL AS WELL AS USEFUL. LET FLOWERS HELP TO MAKE IT SO

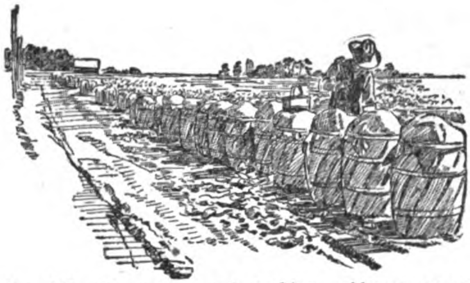


FIG. 445. Harvesting and packing cabbages on a southern truck farm

vesting depends on several points. In the South, quantities of cabbage are used as greens for which purpose the seed is sown thickly in the rows. Thinnings are also thus used. Early cabbage is often cut as soon as the head begins to form but usually not until it is fairly hard. Fall and winter cabbage is allowed to mature fully. Early and small varieties may yield 4 to 5 tons to the acre; late ones 20 tons or more. If to be stored on shelves, the stems and ragged outer leaves are cut off; if for pit or root-cellar storage, they may be left for protection and convenience in handling. In outdoor storage, the heads are placed in trenches and packed with earth covered gradually with straw as winter approaches. An improvement on this is a rather deep trench covered with loose boards to support the partly trimmed heads piled 3 to 6 feet high and then covered with straw and ventilated by tiles through the pile and open ends until cold weather.

CAULIFLOWER, the most valuable and delicately flavored of the cabbage tribe, is less hardy and more exacting in its cultural demands than cabbage. It fails in hot, dry regions. Commercially it is grown only in humid areas of long, cool seasons such as those of eastern Long Island. While grown somewhat as a spring and early summer crop, it is most popular as a fall crop. For early cauliflower, the plants must be started under glass or wintered over from fall-planted seed, the former preferred. Cauliflower seed should be sown a week or 10 days before early cabbage is started, as the plants are slow growing. Otherwise they are handled like cabbage plants. The plants must be thoroughly hardened off before being transplanted in the garden, or they may become stunted and fail to produce heads. Early cauliflower should not be set closer than 2 feet asunder, in rows 3 feet apart. Tillage is the same as for cabbage, though liquid manure given when the heads begin to form is often helpful.

Late cauliflower is even more particular than late cabbage as to moisture and coolness. In warm climates, it is harder to grow than early cauliflower because the young plants suffer from summer heat. Ocean and lake breezes favor it because they are moist and cool. Unless late cabbage does remarkably well in a locality, it is not safe to try cauliflower. The plants are started like those of late cabbage but a week or two earlier. Because good seed is very expensive, more care should be given the seedbed and seedlings. It is folly to buy cheap strains of cauliflower. The plants are set 3 by 4 feet or 4 by 4 because they demand abundant moisture. When set closer, except under irrigation, they often fail to make heads.

Blanching. Unless blanched, the heads are likely to be sunburned and injured in flavor. Blanching is done by drawing the outer leaves loosely together and tying them above the head. Unless plenty of space is allowed, the heads may decay. When the heads reach full size, which they quickly do, they should be cut or they will spoil. To determine when to do this, the head may be examined by peering between the leaves on the north side of the plant. As storage (except commercial cold storage) is hazardous, the home supply should be canned.

Forcing. For forcing cauliflower, a cool house with solid soilbeds is necessary. Only the best strains of forcing cauliflower seed should be used. The plants must be kept growing vigorously from start to finish. In the beds, they may be set about 12 inches apart. A night temperature of 45 degrees, and a day heat of 60 to 65 with highly humid air, give best results. At all times, the soil must be moist, but never soggy. Unless the weather be very sunny during head forming, no tying of the leaves is necessary for blanching.

COLLARD. While young, collards resemble cabbage plants. As summer advances, they grow often 3 feet tall but produce no heads. Instead, new leaves are produced as the stem elongates. In the South, the plant is very popular as a substitute for cabbage which suffers from heat; collard withstands the heat. In the North it is little grown. The young leaves gathered from the upper part of the plant are used, though while small, the thinnings are used entire—except for the stems and roots. Seed is generally sown in early spring in rows 2 to 3 feet apart where the plants are to remain, and the seedlings thinned to a foot apart. Only ordinary tillage is needed.

KALE has loose, more or less "curly" leaves with frilled edges. It is perhaps the simplest to grow of all the cab-

FIG. 446. Blanch cauliflowers by tying the leaves up around the head.

bage group; for it will stand extreme heat and drought, and frost that would kill even rutabagas. Without any protection, it survives the winters of eastern Virginia and adjacent Maryland where the seed is sown in the fall for the spring market. Usually the seed is sown thinly in rows 2 to 3 feet apart where the plants are to remain, the seedlings thinned to a foot apart and given ordinary cultivation. Sowings may be made whenever desired from earliest spring to late summer, the hardiest kinds being relied upon for winter use. By successional sowings, the whole year may be supplied in the South, and 6 to 10 months in the North. By picking the leaves a few at a time, the same plants may be made to supply greens all season, the plants merely growing taller. Half-sized leaves are less stringy and more tender than mature ones. Freezing is believed to improve the quality, hence late fall and early spring are the kale seasons. An immense amount of food may be secured from this plant; but compared with cabbage it is strong flavored.

KOHLRABI. When young and tender, kohlrabi is considered a rival of cauliflower in delicacy of flavor; but when mature, it is inedible. Since it is as easy to grow as radishes, it has been called "lazy man's cauliflower." Generally the seed is sown in rows 15 to 18 inches apart where the plants are to remain, and the plants thinned to 6 or 8 inches. The thinnings may be used for greens. For home use, successional sowings may be made at intervals of 10 to 15 days beginning in earliest spring; and a second series of sowings starting in late summer. In hot and dry weather, the plant tends to become woody and strong flavored. Quick growth in moist, rich soil such as produces good radishes is best for kohlrabi. When the swollen stems are not more than 2 inches in diameter, they are usually in best condition. There are both green and purple varieties, but they do not differ in quality.

Herbs

Herbs are a group of plants of which the leaves, seeds, and sometimes the flowers are used chiefly as flavorings or condiments. They are not food plants, but rather food adjuncts. Many of them owe their qualities to an essential oil and were formerly utilized as correctives and even as mild preservatives. Modern practice, in the way of caring for meats in cold storage and by canning and otherwise preserving vegetable foods in good condition for future use, have tended very largely to dispense with these plants in their original uses and they are now employed, if at all, simply because their peculiar flavors are liked. Herbs are used chiefly among the peoples of the warmer regions of the Old World, where the oils and flavorings are better developed, and where they perform the important service of counteracting the natural tendency of materials in such places to quickly decay; equally among us these extracts serve a similar purpose, to a degree, and they appeal to the appetite in spring as the sluggish condition of the system awakens into more activity. Many of the plants yield principles that are utilized in medicine. The herbs are here divided into two groups: (a) the culinary herbs used mainly if not entirely for flavoring; and (b) the pot herbs, commonly boiled and eaten with greens.

Culinary Herbs

Annual, biennial, and perennial plants used to flavor soups, dressings, confections, stews, salads, drinks, pickles, and other culinary dishes. Several are used in perfumery and medicine. Some are also popular as garnishings—parsley especially; and for pot herbs or "greens"—borage and angelica for example. While the great majority are of importance only in home gardens, many are found in local markets, and some—sage, thyme, savory—are grown and used extensively for flavoring sausage, cheese, etc., both green and dried; in the latter case, they are sold either in bunches, or powdered and packed in cans, bottles or cartons. From several—spearmint, peppermint—the essential oil is distilled for use in candy, beverage and medicine making. These and others are often placed in vinegar or alcohol to extract the flavor, and used in similar ways or for culinary purposes—tarragon. The seeds of several—anise, coriander, and caraway—are used in confectionery and cakes; those of dill for pickle making. Most of the species are aromatic, because they contain an essential oil.

Culture. Nearly all culinary herbs thrive in any moderately fertile, well-drained garden soil, but a few enjoy extremes—catnip, hoarhound and hyssop preferring dry soils, spearmint damp or even wet ones. Those which have very fine seeds—thyme, balm, basil,

hoarhound, marjoram, rosemary, wormwood, tansy, and savory—should be started in flats, shallow boxes or seedpans, and transplanted once or twice before being set in the open garden; otherwise very few will grow, because they will be buried by rains. Only the largest-seeded, quickest-sprouting ones should be sown out-of-doors. In field use, they are usually planted as companion crops with other vegetables. Generally the plants should have a place by themselves at one side of the home garden. Indeed a home is hardly complete without some of these plants. They enable the cook to make more appetizing dishes and drinks than can be made without them, and they greatly help in economizing on the food bill because they help to make cheap cuts of meat and "left-overs" pleasing to the palate. All French, German, Italian, and English gardens and cooks grow and use them as necessities. In America we are only beginning to appreciate them at their true value.

ANGELICA. An annual, sometimes perennial, raised from seeds sown in late summer. Self-sows in fall more or less, but is not hard to kill. Stems and leaf stalks are used for salad or roasted candies, or blanched like celery. Leaves are used as a garnish or greens. The oil from the seeds is used for flavoring.

ANISE. An annual, raised from seeds sown in early spring; self-sows in fall, but does not become a pest. Leaves are used as a garnish, flavoring or greens. Oil from the seeds is used for flavoring and in perfumery.

BALM. A perennial, raised from seeds sown in early spring. Also propagated by cuttings, layers or divisions taken at any time during late spring or summer. Leaves are used as a flavoring or salad, and its oil in perfumery and beverages.

BASIL. An annual, raised from seeds sown in early spring. Leaves are used for flavoring, and the oil in perfumery. It is rather pungent, appealing more to foreigners than to Americans.

BORAGE. An annual, raised from seeds sown in spring. Leaves are used as a salad or greens; but unless the leaves are young they are rather rough as salad. Flowers are used for beverages.

CARAWAY. An annual or biennial, raised from seeds sown in late spring. Leaves are used as salad and greens. Roots are like carrots. Oil from the seeds is used for flavoring and in perfumery and soaps. Seeds are very popular in confections and cakes.

CATNIP or CATMINT. A perennial, raised from seeds sown in fall or spring. Likely to take possession of fence rows and neglected places. Flowers are used for bee forage. Leaves are used as a condiment and cat tonic.

CHERVIL. An annual, raised from seeds sown in early spring and late summer. Sow successionally, for in hot weather it soon runs to seed. Leaves are used for seasoning salads and cooked meats.

CHIVES. A perennial, propagated by bulbs and division of clumps taken early in spring. The leaves, used for salads and flavoring, resemble onions in flavor, but come earlier in spring. Flowers are pretty as edging of beds and borders.

CLARY. A perennial, raised from seeds sown in spring. Leaves are used with cooked meats and in dressings. Flowers and tender leaves are used for wine.

CORIANDER. An annual, raised from seeds sown in fall or spring. Seed is used in confectionery, condiments and beverages. Leaves very offensive smelling.

CUMIN. An annual, raised from seeds sown in spring. Seed is used as an ingredient in condiments, curry powder, pickles, soups and pastry. Cultivated for thousands of years. Mentioned in the Bible.

DILL. An annual, raised from seeds sown in spring. Seed is used in seasoning, flavoring vinegar, pickles, and the oil in perfumery. The young leaves used for salads and seasoning. Extensively used for commercial cucumber pickles.

FENNEL. A biennial or perennial, raised from seeds sown in spring. Leaves are used for flavoring in salads. Seeds are used for flavoring beverages and in confectionery, the oil from the seeds used in perfumery. Cultivated only as an annual.

FINOCCHIO or FLORENCE FENNEL. An annual, raised from seeds sown in spring. Bases of leaf stems cooked or used as a salad. When the leaf bases begin to thicken they should be earthed up slightly to blanch.

FENNEL FLOWER. An annual, raised from seeds sown in spring. Leaves used as greens. Seed used for flavoring.

HOARHOUND or HOREHOUND. A perennial raised from seeds sown in spring. Leaves formerly used in cookery and medicine; nowadays in candy. Too bitter for American taste when used as greens or salad.

HYSSOP. A perennial, propagated from seeds, divisions, or cuttings, and seeds sown in spring. Leaves are used in salads; oil in perfumery and soaps. Too bitter for American taste.

LAVENDER. Perennial, sometimes raised from seeds but usually propagated from cuttings and division, taken during spring. Flowers are used to repel insects and as clothes' perfume; as oil in perfumery and sometimes to flavor salads and condiments. Old-fashioned flower used to perfume bridal trousseaux, especially linen.

LOVAGE. A perennial, raised from seeds sown in late summer. Also propagated from division taken at any time during the growing season. The young stems are used in confectionery.

MARIGOLD. An annual, raised from seeds sown in spring. Flower heads are used for seasoning and butter color. Rather strong flavored.

MARJORAM. A perennial, raised from seeds sown in spring. Also propagated from cuttings, layers or divisions at any time during the growing season. Leaves are used for seasoning, and their oil in perfumery, soap, etc.

MINT SPEARMINT. A perennial, propagated from cuttings, offsets, or divisions, taken any time during the growing season. Leaves are used for seasoning vinegar, beverages, and jellies to be used with meat. Likely to become a pest because of its creeping root stocks.

PARSLEY. A biennial, raised from seeds sown in spring or fall. Roots of some varieties are used as vegetables like beets. (See article on parsley). Leaves are used as garnish, potherbs and for seasoning.

PENNYROYAL. Perennial, propagated from division usually, but sometimes from cuttings, at any time during the growing season. Leaves are used for seasoning and for oil.

PEPPERMINT. A perennial, propagated from division, offsets or cuttings at any time during the growing season. Leaves and succulent stems are used for oil in flavoring, beverages and for scenting soaps, etc. Likely to become a pest because it spreads badly.

ROSEMARY. A perennial, raised from seeds sown early in spring. Also propagated from cuttings, divisions or layers, taken during spring and early summer. Leaves are used for seasoning, and oil for perfumery, soap, etc.

RUE. A perennial, raised from seeds sown in early spring. Also propagated from cuttings, layers, or division taken in spring and early summer. Leaves are used for flavoring cooked dishes, beverages, and the oil for aromatic vinegar and toilet articles.

SAGE. A perennial, raised from seeds sown in early spring. Also propagated from division, layers, or cuttings taken in spring and early summer. Leaves are used for seasoning dressings, sausages, cheese, etc., and the oil used in perfumery. Needs slight winter protection in cold climate. Holts Mammoth is largest-leaved variety. It bears no seeds.

SAMPHIRE. A perennial, raised from seeds sown in late summer and early fall. Leaves are pickled in vinegar, sometimes used in "mixed pickles."

SAVORY, SUMMER. An annual, raised from seeds sown in early spring. Leaves and young tips of stems are used for seasoning stews, soups, dressings, etc.

SAVORY, WINTER. A perennial, raised from seeds sown in early spring. Also propagated from cuttings, division and layers, taken in late spring and early summer. Leaves and young tips of stems are used for seasoning.

SOUTHERNWOOD. A perennial, raised from seeds sown in spring. Also propagated from cuttings taken in early summer. Leaves and young shoots are used for flavoring cakes, confections, etc.

TANSY. A perennial, raised from seeds sown in

spring. Also propagated from division. Leaves are used for seasoning. Too strong flavored for American palates. Plants likely to become a pest.

TARRAGON. A perennial, propagated from layers, cuttings and division, taken in spring. Leaves and young growths are used as salads, in dressings with meats and fish; in vinegar and sauces; oil in perfumery and toilet articles. Produces no seed. Needs protection in cold climates. A substitute similarly flavored, easily grown from seeds is Tagetes lucida.

THYME. A perennial, raised from seeds sown in early spring. Also propagated from cuttings, division, and layers, taken in spring and early summer. Leaves and young shoots are used for seasoning sausages, dressings, etc.; oil in perfumery, soaps, etc.; crystals as disinfectant.

Pot Herbs

Those plants, grown for their leaves which are used as "greens," require an early soil rich in readily available nitrogen to insure quick growth. From the start, shallow surface tillage is necessary. Top-dressings of nitrate of soda are also helpful, especially as the plants approach edible size. The majority of these crops do best in cool weather—spring and fall. With few exceptions, they are short-season crops, so work well as companion and succession crops with other vegetables. To supply the table with greens the entire season, spinach is best for spring, late fall, and early winter; dandelion, pe-tsai and orach are spring crops; mustard an "anytime" crop by successional sowings; purslane, early summer; New Zealand spinach from midsummer to frost; and chard, summer and autumn.

BEET TOPS are the leaves of young beets, which make an acceptable substitute for spinach. The thinnings of the beet rows may be thus utilized, the entire plant root and all being cooked. For cultural directions see under root crops (p. 371).

CHARD is a form of garden beets which does not produce a thickened root and is grown for its leaves and thickened leaf stalks. The former are used as greens in place of spinach, the latter as a substitute for asparagus. Except that the rows should be 24 to 30 inches apart and the plants 15 to 24 inches asunder, the cultivation of chard is the same as that of garden beets. Thinnings make good greens. By cutting the leaves every week or 10 days the plants may be kept producing from early summer until killed by frost.

FIG. 447. Swiss chard

CORN SALAD or FETTICUS, a salad and pot herb which resembles a small-leaved spinach, is a hardy, cool-season crop which reaches edible size in 6 or 8 weeks. It may be handled exactly like spinach in fall or spring sowings. In both America and Europe it is much less grown than spinach.

DANDELION. People who like wild dandelion greens will like cultivated ones better because these may be gathered and cleaned quicker, they are tenderer, and they do not become weeds when properly managed. The French varieties are the best. For outdoor culture, the seed is sown thinly in early spring or sometimes in late summer in rows 15 to 25 inches apart. The plants are thinned to 6 or 8 inches apart. The former gives a crop in the fall and again in spring; the latter only a spring cutting. For coldframe culture, seed is sown in midsummer and the ground worked over between midwinter and spring to a succession crop of perhaps beets or carrots. After harvesting, the out-door plants are turned under to prevent their going to seed. The ground is then used for a succession crop such as tomatoes, melons, or sweet corn. Thus the plant, though a perennial, is treated as an annual. Harvesting consists in cutting the rosette or whorl of leaves so as to include perhaps half an inch of the root crown for easy handling. This crown is cut off when preparing for the kettle. Sometimes the leaves are blanched under inverted flower pots or by tying the leaves above the crown (See Endive, p. 374) A leading point in favor of the dandelion is that it will produce early greens in climates too cold for spinach and even kale.

DOCK and SORREL are closely related perennial herbs sometimes cultivated for the leaves produced for 4 to 6 weeks in early spring, which are used as greens. The leading cultivated varieties are *Spinach Dock*, a week or 10 days earlier and more agreeably flavored than *Large Belleville* which is very sour, and *Round Leaved*, probably pleasing to the majority. The last two are really sorrels. All are of simplest culture like outdoor rhubarb.

MUSTARD, a plant related to cabbage, is used both as a pot-herb and a salad, and its ripe seeds as a flavoring in pickles and for "ground" mustard. For salad purposes, the plants are used when only 2 or 3 inches tall; for greens 4 to 8 inches, depending on the variety. In England and the southern U. S., mustard is more popular than in the northern states. Some of the curled-leaved varieties, like *Fordhook Fancy* and *Southern Giant Curled*, are among the best pot-herbs. The smooth-leaved kinds like *Elephant's Ear* and *Chinese Broad Leaved* are coarser but perhaps as well flavored. Seed is usually sown successionally in early spring and late summer; unless in a cool, moist situation, summer sowing are likely to become stringy, strong flavored and to "run to seed." Sow rather thinly—about an ounce to 400 feet of row—in rows 12 to 15 inches apart. Only the simplest tillage is necessary. Plants should be ready

for use in 3 to 5 weeks. By shearing the plants so as to leave an inch or two of stem still in the ground, a second cutting may be made.

ORACH or FRENCH SPINACH makes good late spring greens. As the seed germinates poorly, it will be more practical to grow other pot herbs instead. The red variety is handsome enough for ornament. Once started it is easy to grow.

PURSLANE or PUSLEY is a hot-weather pot herb. The seed is sown in spring where the plants are to stand. It will not germinate till the soil warms up. The plants mature quickly and may be used before midsummer. Though "pusley" is known as a bad weed, the improved varieties are not likely to give trouble from self-sowing.

SPINACH, the most widely grown "greens" crop, is cultivated both in coldframes and out-of-doors. Its season thus ranges in the northern states from about October until June. During warm weather, its leaves become tougher and it rapidly runs to seed so other greens must be grown to supply the summer needs. The principal objection to it is its dirtiness; even several washings often fail to rid it of grit. This, perhaps, is worst in the Savoyed or wrinkled-leaved varieties. In one group of varieties, the seeds have prickles which make seed sowing difficult, even painful; but these varieties are largely planted for winter use because they are hardier than those of the other group, the round-seeded kinds. In recent years, hardy round-seeded kinds have been developed. Leading varieties are *Bloomsdale*, *Viroflay*,

FIG. 448. Carrots, beets, and other roots can be stored for winter in boxes of sand kept in a cool, moist cellar.

Round-leaved, *Savoy-leaved*, *Long-standing Summer*, and *Prickly*.

Since spinach grows best in cool, moist weather, it is sown in late summer or early fall for autumn, winter and spring use, also in early spring for use before midsummer. In commercial practice, the soil is deeply tilled and thrown into broad, flat beds 4 to 8 feet wide, the width depending upon whether 5 rows 8 inches apart or 8 rows 10 inches apart are used. These are minimum and maximum distances and numbers of rows to the beds. Between beds, spaces of 15 to 18 inches are left for paths. The seed is drilled in. For the home garden, this method is recommended, though often the seed is sown broadcast and merely raked in. One ounce of seed will plant 100 to 150 feet of row; 10 to 12 pounds an acre. When the plants have developed their first true leaves, they are thinned to 3 to 6 inches apart. Ordinary cultivation and weed killing are all that is necessary. In cold climates, straw is usually scattered over the beds to prevent heaving and settling of the soil; but in mild locations such as southern New Jersey, this is not necessary as most of the plants survive the winter. Cutting may begin 6 to 8 weeks after sowing, and continue all winter and early spring. Spring-sown spinach is usually planted in drills 12 to 15 inches apart, given clean wheel-hoe tillage until the most forward plants are nearly large enough to cut. The seedlings are rarely thinned. Should the soil or the season be dry, unless irrigated, the plants will be stunted and suffer seriously from attacks of insects.

Harvesting is done as soon as the large succulent leaves form a good rosette. Sometimes the plants are pulled. For home use the best ones are usually cut with a knife just below the leaves. A better way is to use a sharp scuffle hoe. Where a whole row is to be gathered at once, a wheel hoe is often used. It is an advantage to gather spinach in the early morning before the dew has gone, to wash it at once and then pile it loosely in a shady place covered with wet burlap. This enables it to be shipped to market without wilting. For home use only, the early gathering is necessary.

Enemies. *Green fly* or *aphis* are sure to find failing spinach plants. Cool weather and rain are the best remedies. Soils lacking in humus and those excessively enriched with commercial fertilizers seem also to favor these insects. *Rust* also attacks stunted plants. Rich soil and ample moisture are the best preventives.

SPINACH, NEW ZEALAND, is not a spinach at all, but a substitute that does best in hot weather when true spinach fails. It is a trailing plant which often spreads 4 feet and from its main stems sends up numerous leafy branches. These are cut for use while succulent. Of all "greens," the writer consid-

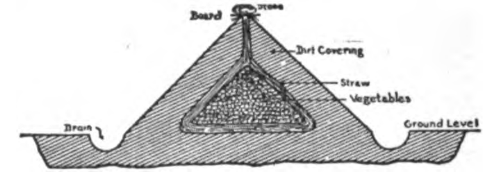


FIG. 449. A good way to store roots outdoors. Notice the straw ventilator at the top of the heap

ers them best as they are not only fine flavored, stringless, and tender, but they require far less washing than any other "greens" to free them from grit. Seed may be sown at any time in spring, but it will not germinate until the soil becomes warm. Rows should be 4 feet apart and the plants thinned to stand not closer than 18 inches. Seedlings started under glass are difficult to handle as they run to seed if checked. Only ordinary shallow surface tillage is needed. When the plants have spread a foot or more, cutting may begin. If at least one leaf is left below each cut, new shoots will develop. Thus the same plants can be cut each week until frost kills the plants. A dozen to a score of plants in rich moist soil should supply an ordinary sized family with one or two dishes a week for about 3 months.

Root Crops

Root crops comprise those plants whose edible fleshy parts grow at or beneath the surface of the soil. While not of so high food value as peas, beans and the grains, they are invaluable for their dietetic effects, providing food materials that are health-giving as well as nutritious. Most of them are easily grown, thrive on a variety of soils, are easy to store, and keep well. They are produced cheaply, often as companion or successional crops. The seed is inexpensive, as a rule, thus the initial cost is much less than that of many other garden crops. All root crops are hardy and easy to grow. They resist frost and succeed best in a cool season, hence do best in northern latitudes and high altitudes. Those that require only a few weeks to reach edible size do best as spring- or autumn-sown crops. They become "strong" or "run to seed" in hot weather. Long-season root crops, though usually sown early, make little root development during dry weather, but rapidly increase in size during the moist autumn months, and are, therefore, left in the ground until the near approach of winter. Some—notably parsnips and salsify—may be covered heavily with straw during winter to prevent deep freezing and allow digging, or they may be left wholly unprotected until spring.

Soil. Root crops require deep soil because their value depends mainly upon their smoothness and size. If the soil is shallow, hard, heavy, or full of stones and clods, the roots grow short, branchy, irregular, and of inferior quality. Finely pulverized soils, especially if dark-colored and warm, hasten growth and improve quality. While root crops require ample moisture, the soil must be well drained or it will be cold and shallow in effect. To deepen, enrich and otherwise improve soils for root crops, the use of sweet clover (melilotus) to be plowed under as green manure is specially good on heavy soils underlaid with clay. Mammoth clover is recommended for ordinary soils.

How to grow them. Seed is generally sown in drills in the garden and the plants thinned; For autumn cropping, turnips, rutabagas, and radishes are sometimes sown broadcast in July, August, or September, among crops such as tomatoes, melons, and corn and allowed to shift for themselves. Only a small proportion of the plants then reach edible size; the rest are plowed under to improve the

FIG. 450. Digging out parsnips stored as shown in Fig. 449, for winter and early spring sale

soil. Except in a very small way, root crops are not transplanted, because their long tap roots, unless very small, make them difficult to handle successfully. Some kinds mature so quickly that they may be sown successionally immediately before or after some other crop the same season; or as companion crops in alternate rows with longer-season crops which they leave in full possession of the ground when they are harvested. Other kinds demand the whole growing season in which to reach maturity.

In general, root crops can utilize plant food in cruder form than other vegetables. They are greedy for potash, but also demand plenty of nitrogen and phosphoric acid. To help them start quickly, a light dressing of nitrate of soda, or sulphate of ammonia, is helpful, especially with the short-season kinds needed at some specified time. As a group, root crops demand more plant food than do legumes or grains, and therefore exhaust the soil more. They are excellent to follow other crops that leave much plant food in the soil, such as peas or beans. *Cultivation* consists merely in keeping the ground open and free from weeds until the plants shade it.

Harvesting and selling. Except in the case of the very short, bulb-like roots, harvesting calls for the heaviest work in growing them. Medium-length roots may be loosened with a celery digger; longer ones may be plowed out; and the longest, if too deep-rooted for either of these methods, may have a deep furrow or two thrown away from them on each side and perhaps a subsoiler run in the bottom of the nearest furrow, so that hand pulling may be made easy. Rarely is hand-pulling necessary. When dug, the tops of roots to be stored are cut off an inch or so above the crown. After lying in the wind until the soil upon them will shake off, the trimmed roots may be sold or stored in bulk in pits or cellars. All that is necessary is to keep them cold. A slight frost will not injure any of them. Early roots such as radish, carrots, beets and turnips, are generally sold in bunches with the tops attached. Later, when the price declines, they are sold in bulk. In all cases, they should be of uniform size and neatly trimmed of unsightly roots, dead or yellow leaves, etc.

BEET. A hardy biennial vegetable with a thickened, moderately firm-fleshed large root, universally used and highly valued for food. Garden beets are of two classes, turnip-rooted and long-rooted. In America, the former are much the more popular because more quickly grown and more easily harvested. As they can be harvested in 12 weeks or less, they make good companion and succession crops, sown either in early spring or in midsummer. There are at least 4 types: (1) the garden beet; (2) Swiss chard or leaf beet; (3) the sugar beet; (4) mangel-wurzel. The third and fourth types are considered under Field Crops (p. 282). The second, because its leaves and not its roots are used, is treated on p. 368.

Culture. Each "seed" is really a dried fruit containing 1 to 5 or more seeds, hence sowing must be done thinly. Even then the plants come up in clumps and must be thinned. Often rows are made 6 to 8 inches apart, each alternate one being removed for "greens" when the tops are large enough. The thinnings of the remaining rows are also used for the same purpose. For wheel-hoe cultivation, 12 to 18 inches is a convenient distance. One ounce of seed will sow 75 to 100 feet; 5 to 8 pounds, an acre. Common yields are 300 to 500 bushels mature beets to the acre. For home use, 100 to 200 feet of row in spring and again in fall should supply an average family. While fall-sown beets may be stored like potatoes, a better plan is to can the spring-sown crop while in its prime, during midsummer. If grown too long, the roots become woody, tasteless and hard to cook. Beets often shrivel and deteriorate in storage unless kept cold and moist. *Root rot*, a disease, may be checked by liming the soil; *leaf spot* by spraying with bordeaux mixture; *scab* by choosing only clean land.

CARROT. A biennial with a firm fleshy root, harvested the first year. Not so highly esteemed or widely grown in this country as some of the other garden root crops. Garden carrots are of two general classes, short-season and long. There are 3 types, described by their relative signs as long, half-long, and short-horn. As the seeds are small and slow to sprout the soil must be clean, mellow and kept from baking. Radishes are often of help (p. 180) at the start. Weeds must be kept out of the rows or the little plants will suffer. Sowing may start as soon as the soil can be worked. Quickest growing kinds require 8 to 10 weeks to reach edible size. Drills are made 9 to 18 inches apart. Earliest and smallest varieties are thinned to 4 or 5 inches and late large ones 6 to 8 or 9 inches in the row. An ounce of fresh seed will sow 200 to 400 feet of drill; the former distance in heavy soils without radish seeds, the latter in lighter ones with radish. Early carrots are usually bunched for sale; late ones sold in bulk. Yields vary from 200 to 400 bushels an acre. Fifty to 100 lineal feet of early and an equal amount of late carrots should supply an ordinary family. But canning part of the early crop in midsummer will usually be more satisfactory than storing for winter.

CHERVIL, TURNIP-ROOTED. A small, gray or nearly black-rooted plant but little grown in America. It resembles the carrot in its culture and use except that the roots are improved by letting them remain in the soil until needed. The seed germinates poorly if allowed to become dry over winter. Hence it is generally sown in early fall, though it does not germinate till the following spring.

HORSE-RADISH, a hardy perennial vegetable grown from root cuttings. For success, the soil must be very deep, cool, moist and rich, and the fall must be long, moist and cool. If allowed to grow more than one season, or if the season is dry, the roots become woody. For commercial purposes, the crop is treated as an annual.

Culture. When a crop is harvested, the side roots as small as a lead pencil or as large as one's little finger are trimmed off to make cuttings. They are made 4 to 8 inches long, cut square across the upper ends and slanting below so they may be easily placed right end up when planting. During winter, they are stored in bundles in cellars or pits and kept cool and fairly moist. Sometimes they are planted in early spring in furrows, but usually rather late when they are set between plants of cabbage, beets or other crop that is harvested before midsummer. In the latter case, a long-handled dibble is used to make slightly slanting holes into which the cuttings are dropped so the tops are about 4 inches below the surface of the ground. This purposely retards growth till the early crop has been harvested. Distances between plants vary from 12 to 18 inches and between the rows from 2 to 4 feet. Should the tops appear before the cabbage or beets are gathered, they may be cut off even two or three times like weeds without apparent injury. After the early crop has been harvested, surface tillage only need be given until the horse-radish leaves shade the ground. When treated as a main crop, other crops such as spinach, lettuce and forcing carrots may be grown between the rows.

Fig. 451. Horse-radish roots

Harvesting. When winter is nigh, the roots are plowed out and stored in pits or cellars. Care should be taken to get as much of the root as possible out of the ground, because every piece will grow and the plant may become a pest. Hence even small pieces should be gathered and destroyed if not wanted for propagation. The furrows should be left open till spring to expose still more roots for collecting at that time. Good tillage the following season will usually prevent trouble. When wanted for sale the roots are scrubbed and trimmed and sold either in bunches, in barrels, or in bulk. Preparation for use consists in grating usually in a machine with a revolving "comb" and covering with vinegar in tightly-corked bottles. Preferably horse radish should be used soon after grating as it rapidly loses its pungency. Yields vary from 2 to 5 tons per acre, and the price from $10 to $50 a ton. In home gardens, it is usually allowed to grow from year to year, but this method produces inferior, woody roots.

KOHLRABI (p. 366) though often mistaken for a root crop is really a member of the cabbage family, the edible portion being the stem which swells into a round or oval shape.

PARSLEY, HAMBURG or TURNIP-ROOTED. A form of parsley having blunt roots resembling parsnips and tops like those of ordinary parsley, and used for flavoring. As the plant requires a long season to mature, sow seed in early spring in drills 18 inches apart, and thin the young plants to stand about 8 inches apart. Roots are in season from mid-autumn to spring, and may be stored and used like parsnips, though they have a different flavor. The plant is popular in Continental Europe but little known in America.

PARSNIP is a long-season root crop requiring very deep, rich soil. Sow as early as possible in spring, preferably with radish as a row-marker (p. 180). As the seed radpidly loses vitality, it should be not older than two years or sown more thickly than an ounce to 200 to 250 feet of row. This amount will supply an ordinary family from November to April. Four to 6 pounds of fresh seed is the usual amount sown per acre. Thin the young plants to 6 or 8 inches apart. General average yields run from 500 to 600 bushels an acre. Distances between rows vary from 15 to 20 inches. As the roots are hardy, they may remain in the ground until spring, but for convenience in reaching them and to secure the high winter prices, they are generally stored. Contrary to popular belief, freezing does not improve the quality of parsnips. If not allowed to shrivel the quality of stored roots is as good as of those freshly dug.

RADISH. A quick-growing vegetable, most highly prized for its crisp roots with a pungent flavor, used raw when young and tender as a relish or appetizer. Some varieties are very "peppery," while others, notably the winter ones, are remarkably mild. Occasionally the larger roots are cooked.

Types. Radishes are sometimes divided into three groups; (1) spring and fall, small and mostly globular, like *French Breakfast* and *Scarlet Globe;* (2) Summer, medium-sized, mostly long, like *Long Scarlet, Icicle, Giant White Stuttgart;* (3) winter, mostly very large, like *Rose China* and *Long Black Spanish.* The first are usually red and white; the others include also black and yellowish russet. In America, the first are most popular, both out of doors and under glass in winter; the second are little grown because of the dry seasons; the last still less because less generally known and appreciated, and sometimes coarse. All varieties are partial or short-season crops, requiring rapid and steady growth, cool weather and protection from root maggots to reach perfection.

Culture. The small kinds are popular as companion crops with cabbage, peas, beets, etc. Often they are sown thinly in the rows of other crops to break the soil crust and mark the positions of parsnips, carrots, and other slower germinating seeds, thus permitting tillage to start within a week; as they mature in 3 to 5 weeks, they do not interfere with such crops if gathered promptly. For growth in hot weather, the soil must be moist and preferably partially shaded to keep it cool. Winter varieties may be sown between mid-summer and early fall. Root maggots may be largely avoided by choosing soil where radishes, cabbages, turnips and related plants have not been grown for several years. For uniformity of crop, small seeds should be sifted out and only the large ones sown. Sowing may be done in spring as soon as frost is out of the ground. For wheel-hoe culture, rows are made 12 or 15 inches apart, less for hand work. An ounce of seed will plant 100 feet or more of drill; 8 to 10 pounds an acre. Early kinds are sown thinly to avoid thinning. Summer ones are thinned to 2 or 3 inches; winter ones 4 to 6 inches. For home use, successional small sowings are made 1 or 2 weeks apart until early summer, and again from midsummer to midautumn.

FIG. 452. Three types of radish: Globe or olive-shaped; long (early and summer types); and large winter sorts.

RUTABAGA, or SWEDISH TURNIP, differs from the true turnip in having a denser texture, generally orange-colored flesh, more elongated roots and a large number of fine fibrous roots. In flavor it is richer and stronger than true turnips. While cultivated like them, it is sown far more in summer than in spring. To reach perfection and full size it requires 4 to 6 weeks longer.

SALSIFY or VEGETABLE OYSTER is cultivated like the parsnip. Sow seed in drills in deep, rich, loamy soil, in early spring in rows 12 to 15 inches apart. Thin the seedlings to stand one every 4 or 5 inches. Because of their stick-like form, the seeds are difficult to sow, especially with the seed drill. An ounce will plant 75 to 100 feet of drill, and 8 to 10 pounds an acre. A 100-foot row will produce enough for an average-sized family; an acre, 200 to 300 or more bushels of roots. As these are perfectly hardy, they may be allowed to remain and freeze where they have grown, but for convenience in reaching them, at least part should be dug and stored in a cellar or a pit where they will not shrivel.

SCOLYMUS or SPANISH SALSIFY cultivated like salsify which it somewhat resembles also in flavor. Its chief advantages over salsify are the comparative ease of sowing its seeds and its larger size and productiveness. Almost twice as much can be secured from an equal area. Its chief disadvantage is its prickly leaves which, however, when young and blanched are sometimes eaten uncooked and in salads like celery.

SCORZONERA or BLACK SALSIFY, unlike true salsify, is a perennial the roots of which grow larger each year, but without ever becoming woody. It is handled and used exactly like salsify.

TURNIP. Flattened or almost globular-rooted plants which require 6 to 10 weeks to reach edible size. Generally, they are sown in earliest spring for summer use and in midsummer for fall and winter. The foliage can withstand much frost without injury, so the plants may be harvested very late. The roots are not as hardy as those of salsify and parsnip, so can not be left in the open ground where winters are very cold. Unless grown rapidly, they become woody, fibrous and bitter. For best results, the soil must be moist, rich, and in good condition. For home use, 100 feet each of spring and fall crops should suffice. An ounce of seed will plant 200 to 300 feet and one pound an acre if sown in drills or 2 to 3 pounds if broadcast. Early turnips are sown in rows 9 to 18 inches apart for hand and wheel-hoe cultivation, 18 to 30 for horse. Thin the plants, first to stand 3 inches apart, then, when some are large enough to eat, leave one every 6 inches, and at the third thinning, one every 12 inches or so. Frequently the fall crop is broadcasted among corn, tomatoes, melons and other vegetables, but better results follow drilling. Yields range from 600 to 1,000 or more bushels an acre.

Salad Crops

This is a group of vegetables of delicate texture, eaten in a fresh growing state. In general they demand much the same conditions as pot-herbs, but in an advanced degree, for while all vegetables are best when fresh, salad plants must be fresh or they are worthless. Hence the home gardener is the only person who can have salad plants at their best for they must be kept growing vigorously to within 30 minutes of being served! Rich soil, ample water, clean tillage, favorable weather give best results.

CELERIAC or TURNIP-ROOTED CELERY is a form of celery in which the thickened root is the desired edible part. It is used, cooked, as a flavoring or as a salad. The plant is dwarfer than celery, needs no blanching but is otherwise handled like celery (p. 380). In the garden, 6 or 8 inches between plants and 18 to 30 inches between rows are common spacings. In winter, the roots may be kept in moist sand. Well-grown roots are 3 to 4 inches in diameter.

CHERVIL. An annual herb resembling parsley, used for seasoning and garnishing. Seed sown in early spring or fall will give cuttings of leaves in 6 to 8 weeks. The plant quickly runs to seed in hot weather unless in a cool situation. In mild winters, fall-sown plants need but little protection to live until spring, and thus start the season before spring-sown plants would be ready for use. In the garden, the plants should be 8 to 12 inches asunder in rows 18 to 24 inches apart. This is not at all the same plant as turnip-rooted chervil (p. 371).

CORN SALAD. On account of its exceptional hardiness and extreme earliness, this is one of the most popular salad plants in some sections. It can be had all through the winter from the open ground. For details see under "Herbs" (p. 368).

CRESS or PEPPERGRASS, a piquant salad somewhat resembling water cress in flavor, may be grown in flower-pots or boxes indoors during winter. Out-of-doors the seed may be sown successionally every week from opening of spring until early summer. It will be ready to cut in 3 to 5 weeks. If sheared so as to leave an inch or so of stems, a second and sometimes a third cutting may be secured. As it quickly runs to seed in hot weather, no sowing should be made until late summer when a second series may be started. Eaten with salt or with mayonnaise dressing, it is excellent alone or mixed with less highly flavored salad plants such as corn salad and lettuce.

CRESS, UPLAND UPRIGHT. A hardy biennial herb cultivated as an annual usually sown in the fall for early spring. In form and flavor, it suggests water cress but is more pungent. It grows in ordinary garden soil. As the leaves lie flat on the ground, they often become soiled. Though the plants are slower to run to seed than garden cress, the leaves soon become bitter and strong flavored. They may be used for greens as well as for salad.

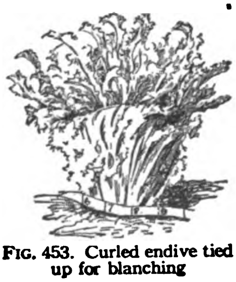


FIG. 453. Curled endive tied up for blanching

CRESS, WATER. A hardy perennial aquatic plant common in spring brooks, and cultivated in shallow ponds with running water, and in rich soil that can be kept absolutely moist. The seeds may be sown in brook margins where they will not be washed away, or in wet soil in the shade, under greenhouse bench or out of doors. Short pieces of the stems, especially those already rooted, are even better because they become established sooner. Where the brook does not freeze, cuttings may be made all winter and through spring. The plant becomes strong flavored as blossoming time approaches.

DANDELION though usually considered a pot herb (p. 368) is an excellent early season salad the whole young crown being cut off and served like lettuce.

ENDIVE. An autumn and early winter salad. It makes a thick mass of curly leaves usually bitter flavored and often tough even when blanched. While best results are secured in cool weather, seed must be sown before midsummer. The plants stand heat and drought well, so the seed may be sown where they are to remain, or they may be transplanted from a seedbed. They may stand 12 inches asunder in rows 15 to 18 inches apart. Good tillage and ample water are necessary to best quality. Blanching is done by tying the outer leaves over the crown of the plant or covering with a large flower pot. The plants should be used in 2 or 3 weeks or the centres may decay. Hence for home use, only a few plants should be blanched at a time. They must be dry when tied up or they may rot.

ENDIVE, FRENCH, or Witloof Chicory, is fast becoming a popular winter salad and is easily grown in any ordinary garden soil, wherever beets can be grown. Sow seeds thickly in drills 18 inches apart in spring and take up the roots in fall, putting them in sand boxes in the cellar, or packed tightly in a frame outdoors. The object is to force the leaf growth from the crown by overhead heat, as by piling hot manure on top of the crowns. The young growth, like small cos lettuce or romaine, is then drawn up and blanched until ready to cut and serve with dressing. Roots will produce for several weeks. Another way of growing is to plant in long beds a foot wide and board up before winter so as to be ready for the forcing material at convenience

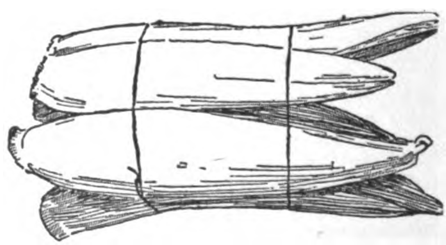


FIG. 454. A bunch of blanched French endive shoots

during the cold weather. It takes about 2 weeks to force.

LETTUCE is the leading salad crop of America. It is a hardy, cool-season, quick-growing annual herb, always cultivated as a companion or a succession crop. Lettuce does best in cool weather or in a shady place during summer, though the cos or romaine varieties will stand summer heat better than the others which develop seed shoots. If well hardened, the young plants will resist even more cold than cabbage—even 12 degrees below freezing point. But mature plants will stand only a few degrees. In eastern Virginia and southward, they pass the winter without protection. On Long Island they often live over winter, but a light mulch usually insures success.

Types and varieties. The numerous varieties are of 3 main classes: (1) heading, in which the leaves form a cabbage-like head —*Big Boston*, *Hanson*, *California Cream Butter*, *Black Seeded Tennis Ball;* (2) loose leaf which do not form solid heads and generally a lettuce for hot weather or dry soils: *Grand Rapids Forcing*, *Black Seeded Simpson*, *Prize Head*, *Simpson Early Curled*; (3) ***Cos or Romaine***, which are a distinct type, long pointed and of harder, crisper texture: *White Self Folding*, *Trianon*, *White Paris*, and *Red Cos;* the first two groups also divide into butter head and crisp head according to texture. Heading varieties are most popular in the eastern U. S., with cos kinds gaining in favor because of their high quality; cutting or loose leaf kinds, especially *Grand Rapids*, are most used in the West. It is important to select varieties fitted to the season as fall varieties do not do well early in the year, and vice versa.

Soil. Rich, warm sandy soils generally give best results with early lettuce, though cos varieties are said to do well on clay loams, and *Grand Rapids* on all kinds of soil. Heading varieties fail on compact soils. They are largely grown in muck beds and on sandy soils. Whatever the nature of the soil, it can scarcely be too rich because lettuce is a gross feeder, and needs constant watering. Success in cultivation lies in keeping growth active.

Culture. Several ways of starting are popular. (1) In early fall, sow seed out-of-doors and transplant the seedlings a month or 6 weeks later to cold frames, protect with sash and straw mats over winter, and either set them in the field or leave them in the frames until ready for use. (2) In early spring, sow in a cold frame or a hotbed 5 or 6 weeks before the ground out-doors can be worked, and transplant direct to the garden. (3) A better plan is to start in the greenhouse 8 to 10 weeks before the ground can be worked and when 3 weeks old to transplant 2 x 2 inches apart to flats kept in cold frames until the spring opens. (4) Sow in the open ground in early spring, and thin the seedlings at first to 1 inch apart. When the thinned plants begin to crowd, pull each alternate one for table use. When the remaining ones touch, repeat the process, thus leaving the plants 4 inches apart. (5) Another plan is to make small successional sowings 1 or 2 weeks apart from early spring until summer, and again from late summer until early autumn. The rows may be 15 to 18 inches apart. When lettuce plants are used for transplanting, they may be set alternately with cabbage or other slower growing plants; also in alternate rows. They are harvested before the cabbage needs the space. Weekly hoeings with the wheel-hoe are desirable. Irrigation by the overhead method (p. 36) enhances crispness, high quality and early maturity. It also delays seeding, and makes summer growing less hazardous.

FIG. 455. Three types of lettuce. Above, loose leaf; centre Cos; below cabbage or solid head.

PARSLEY, a biennial herb the leaves of which are used extensively for garnishing, and flavoring soups, stews, and salads. As the seed is slow to sprout, it is either sown in a small bed from which the seedlings are transplanted, or radish seed is sown with it to mark the rows (p. 180) if in the open ground. The plants needed should stand 8 or 10 inches asunder in rows 12 or 15 inches apart. Only ordinary cultivation is needed. In about 3 months, the first leaves may be gathered. These should be only the fully developed, dark green ones on the outside or lower part of the rosette. The younger ones have not enough substance to "stand up," and their removal would injure the parent plant. The leaves may be easily dried by spreading thinly on cheesecloth sheets supported on light frames so there will be free circulation of air. A warm attic or a dust-free loft are good places for drying. When fully dry, they may be powdered by hand rubbing, and after the stems are removed, stored in stoppered bottles. For a fresh supply during winter, plants may be dug at the approach of winter, and planted in flower pots or boxes, or grown in a cool greenhouse or a

coldframe. They are even easier to grow than ordinary house plants. A supply may thus be secured until May by which time the outdoor plants will be ready. As the latter soon run to seed, however, a fresh supply of plants should be grown each year. A score of plants will supply an ordinary sized family.

Vine Crops or Cucurbits

All these are annuals, tender to frost. They do best in warm weather and in the full sun. While summer squash will yield edible fruits in 60 to 70 days, pumpkins, winter squash, melons and cucumbers need 100 to 125. In cool sections of the country, therefore, they must be grown quickly, and protected while small, or the early autumn frost may catch them before maturity. While sometimes grown in rows with 1 to 3 feet between the plants, the usual way is in hills with 2 or 3 plants in a hill. Usually they are grown in the open field or garden, but often (especially pumpkin and winter squash) among tall crops such as corn. Frequently they are started under glass in pots, boxes or inverted sods 4 to 6 weeks before being transplanted to the open ground. These give earliest fruits, the out-door-sown plants forming a succession. In the North, this is often the only way in which they can be successfully grown. Much care is necessary, however, in operating it because transplanting is difficult with all of them. The ball of earth around the roots must not be broken. In all cases, they do best in well-drained sandy soils that warm up quickly and retain heat well. Richness is essential to greatest success. The soil should contain abundance of decaying vegetable matter preferably from a heavy clover sod plowed under in early spring.

Fertilizing. Previous to plowing, 30 or 40 tons of well-decayed manure should be broadcasted on the area. In addition many growers apply 500 to 1,000 pounds an acre of a fertilizer containing 300 pounds of nitrate of soda, 700 of cottonseed meal, 750 acid phosphate and 250 potash, a couple of weeks before planting. Others mix a liberal shovelful of well-rotted manure with the soil where each hill is to be in addition to all the applications already mentioned. When manure cannot be secured, commercial fertilizer may be mixed in the hills, care being taken to avoid having it touch either the seeds or the *newly transplanted* plants, otherwise these would be destroyed.

Prolonging the season. The harvesting season may be extended considerably, with summer squashes and cucumbers by gathering the unripe fruits when just in prime condition for the table. New fruits will form and production thus be made a continuous process until frost. The idea is that as seed is not allowed to mature, the plants will continue to make fresh efforts to form new lots of it.

CANTALOUPE or MUSKMELON. When well grown, this is one of the choicest of warm-weather fruits. It has countless varieties of which leading ones may be grouped into types as follows: *Jenny Lind* type, usually less than 3 pounds, *Jersey Belle, Emerald Gem, Christiana* and *Shippers' Delight; Rocky Ford* type less than 3 pounds, *Golden Gem, Pineapple, Paul Rose, Netted Gem*—the leading type of commercial cantaloupe; *Hackensack* type, 3 to 6 pounds, *Ironclad, Chicago Nutmeg, Early Nutmeg, Irondequoit, Satisfaction, Long Island Beauty, Perfection* and *Surprise; Montreal* type, 3 to 6 pounds, *Tip Top, Miller's Cream, Chicago Market* and *Green-Fleshed Osage; Cosmopolitan* type, 3 to 6 pounds, *Anne Arundel, Honey Drop, Netted Nutmeg, Lone Star* and *Triumph; Long Yellow* type, 6 pounds or more, *Cassaba, Long Yellow* and *Granite State; Bay View* type, 6 pounds or more, *Large Black Paris, Large White French* and *Bay View*. Though many of these are grown for local markets, the great shipping melons are all of the Rocky Ford or Netted Gem type.

In the garden, cantaloupes are usually set 4 by 6 feet, though the early kinds may be 4 by 5 feet. Often the early kinds are started, and 2 or 3 weeks later, the late crop is planted between the early hills. Usually, 2 plants or only 1 are allowed to each hill. When so managed, 3 or 4 good fruits may be produced by each vine. When more thickly set, the number of fruits may be larger but the size smaller and the quality poorer.

CUCUMBER. A fruit usually used while immature for salads and for pickles. The little ones—1½ to 2½ inches long, called gherkins—are used for sour and sweet pickles and for mixtures; when 4 to 5 inches long, they are made into dill pickles. Larger sizes are used for slicing. Occasionally nearly ripe ones are cooked. In the garden, the hills are usually made about 4 by 4 feet apart for early kinds; 4 by 6 for late. Generally 3 to 5 plants are

allowed to remain in each hill. An ounce of seed should plant about 75 hills and 2 pounds an acre. Popular varieties are: *Early Russian* for earliest, *White Spine* of various strains for main crop. For pickling only, *Boston Pickling, Fordhook Pickling,* and *Chicago Pickling* are popular.

PUMPKIN. In all respects the pumpkin may be grown and stored like winter squash (see below). Among the leading varieties are *Cheese, Mammoth, Winter Luxury, Connecticut Field, Potiron,* and *Yellow Sweet Potato.*

SQUASH. There are several distinct groups of squashes. The summer or bush varieties do not "run" so may be planted as close as 4 by 4 feet apart each way though 5 feet will often be better. These varieties are mostly of odd form as their names imply: *Crookneck, Pattypan, Pineapple, Scallop.* The *Pattypan* and *Scallop* varieties are popularly called *Simlins* in the South. Another specially good variety because of its oblong shape is the *Vegetable Marrow.* It is easier and less wasteful to prepare for the table than the irregular and warty varieties unless these be gathered very immature and cooked skin, seeds, and all.

The winter varieties are rampant growers so need 10 to 12 feet between hills. While they vary in form from oblong to pointed and very irregular, they are less remarkable than the summer varieties. Among the best are *Hubbard, Boston Marrow, Delicata, Golden Bronze, Essex Hybrid, Dunkard,* and *Mammoth Whale.*

Squashes may be stored successfully for winter if harvested and handled without bruises before frost, short stems being left attached. It is essential that the rooms in

FIG. 456. Types of squash and a pumpkin (*f*): *a* Turban; *b* small Hubbard; *c* Crookneck; *d* Pattypan; *e* Vegetable Marrow.

FIG. 457. The ability to tell when a watermelon is ripe comes only with experience

which they are stored be warm, not less than 50 degrees F. Bins and racks are equally popular. When properly managed the later varieties may be kept until late spring or early summer. If a sweet-potato house is available, the two vegetables may be stored under the one roof as storage conditions are practicaly the same.

WATERMELON. If anything, the soil for this crop should be the lightest and warmest of all on which the vine crops are grown; otherwise the general directions given above will apply here. Among the many varieties, the following popular kinds are typical: *Kolb Gem, Cuban Queen, Halbert Honey, Kleckley Sweet* (or *Monte Cristo*) *Dixie, Sugar Stick, Florida Favorite, Cole, Fordhook, Phinney,* and *Ice Cream.*

Distances between hills for early varieties may be as close as 6 by 6 feet; for later and large-growing kinds, as much as 12 by 12 where the soil is rich. Probably 10 by 10 is the most popular distance. Sometimes the plants are placed singly in rows 3 or 4 feet asunder, the rows being 8 to 12 feet apart.

No fruit is more often picked "green" by the amateur than is the watermelon. One way to decide is to note the condition of the tendril or "curl" opposite the fruit on the vine. It usually dries up and dies just about the time the fruit is ripe. A safer way is to note the color of the under side of the fruit. It generally turns from greenish white to cream color. Another way is to "flick" or "snap" the fruit with the middle finger. If it gives a sort of ring, it is still green, but if it gives a dull thud it is ripe. All these tests are inferior to the experience that recognizes a ripe melon at sight. The skin becomes somewhat duller and firmer at maturity. This stage should be learned if many melons are grown because it saves much time in harvesting and is even more certain than any of the other methods mentioned.

Miscellaneous Vegetables

While some of the following crops are more or less closely related, their adaptations, requirements, treatment or use differ sufficiently to make it best to discuss them separately. In some cases, that of the potato for example, the same

crop is a very important feature of extensive specialized or general farming. In this chapter, however, such crops are viewed entirely as garden plants. For their cultural methods as field crops see Chapter 26.

ARTICHOKE, GLOBE or FRENCH. A thistle-like perennial herb with ornamental, slightly woolly leaves and a blossom stalk often more than 3 feet tall. The base of the large young bud (the size of a man's fist) and its fleshy scales are eaten after being boiled and either served hot with a cream dressing or cold as a salad with French dressing or mayonnaise. If the bud is allowed to mature, it becomes stringy, tough, coarse and useless for food. In America, this artichoke is seldom grown except in the coast states from Long Island southward, in California and in the Gulf States where it is being raised commercially to supply the best hotels and the fancy trade in the North. The plant is somewhat tender to frost and, north of the Carolinas, must be protected over winter in any way that will not choke the plant.

FIG. 458. Globe or French artichoke

The plants are grown from seeds or suckers; seeds give bearing plants the following year. A start is usually made with seeds sown during February or March in a greenhouse, hotbed or the dwelling in the North, and out-of-doors in the South. When the little plants have their first true leaves, transplant to 2-inch pots, and, when their roots have formed a mat around the ball of earth, to 3-inch pots. As soon as danger of frost has passed, plant in the garden 2 to 2½ feet asunder in rows 4 feet apart in rich sandy loam well supplied with moisture during the growing season but well drained, especially in winter. Many of the plants will bear edible buds the first season. Destroy all inferior ones and mark the choicest for propagation by suckers next spring. As suckers appear on the marked plants, remove them carefully with a small piece of the main stem and set at once where the plant is to stand. These suckers will produce edible buds the first year.

Artichoke, Jerusalem or American. A hardy perennial herb the tubers of which are used as a vegetable and a stock food. Few vegetables excel it in delicacy of flavor when escalloped or steamed or boiled and served with Hollandaise or cream sauce like cauliflower. It must not be compared with the potato, because its cooked tubers are always soggy. It may be left in the ground over winter without injury; indeed, this is better than storing in dry quarters of any kind. In food value, it is about the same as the potato. No crop is easier to grow. The tubers are planted in rows 30 to 36 inches apart and about a foot asunder. Any fertile soil will do. Cultivation is a help. As the digging never removes all the pieces of tuber, a second planting is never necessary. An area should be set apart as permanent quarters for the crop. Should the patch begin to spread too much, a few hogs confined on it for several days or weeks during fall or spring will clean up the place.

ASPARAGUS. A hardy perennial herb widely cultivated for its young shoots which, when boiled or steamed, are used hot with sauces or cold as salads. Because of its ease of culture and its permanence, it should be in every home garden. With good care, a home bed should last 10 to 25 years. Commercial plantations generally continue profitable for 5 to 10 years.

Varieties. While there are several varieties—*Conover's Colossal, Palmetto* (or *Argenteuil*), *Columbia White Mammoth, Barr's Mammoth, Reading Giant,* etc.—they differ so little in size, form, appearance and yield that it is doubtful whether they are really varieties. What is more important is "strain." As ordinarily grown, asparagus is subject to "rust" (see below) but by selecting seed from healthy plants, the seedlings are likely to be more resistant to the disease than those grown from seed of random gathering. Another important point is that "male" plants produce much larger, stronger stalks than do "female" plants. The difference between the plants is not easy to note until the plants begin to form seeds, when the "females" or seed-bearing plants may be discarded, although this is not often done.

Propagating. Asparagus is started from seeds sown out of doors in early spring. As the seedlings are very inconspicuous, it is well to sow a few radish seeds to mark the rows (p. 180) which should be 15 to 18 inches apart for wheel-hoe cultivation, and in which the seeds may be dropped 1 or 2 to the inch. In 3 or 4 weeks, the radishes must be removed and the asparagus thinned to 4 or 5 inches between plants. No further care is needed other than clean cultivation. If desired, the plants may be set in permanent quarters the following spring. It is better to transplant them a foot asunder in nursery rows 2 feet apart so as to make them stocky and so the "female" and other inferior plants may be discarded. Plants so selected and

transplanted are worth far more than the ordinary two-year-old plants sold by nurserymen.

Permanent beds. In the final beds, the plants may stand 18 to 30 inches asunder and in rows 3 or 4 feet apart where green "grass" is the object, and in rows 6 to 8 feet apart where "blanched" or "white grass" is desired. Green "grass" may be produced in any soil, but white requires light soil. Any soil that is not wet will grow asparagus, but rich, warm, well-drained soils give best results. Preparation must be thorough. The land should have been in cultivation and free from perennial weeds for at least a year before planting. In early spring plow deeply and subsoil to form a loose bed at least 15 inches deep. Make trenches 10 inches deep at the desired distances with a liberal dressing of well-rotted manure worked into the bottom or covered with 2 or 3 inches of soil. On this, the crowns must be placed with their roots spread out in all directions, and at first covered with only a couple of inches of soil, leaving 6 or 8 inches of trench to be filled gradually by cultivation so that by fall the ground will be practically level. Cultivation is the same as for corn each year. No cutting must be done until the bed is starting its third spring, when a few stalks may be cut. Full cutting may begin the fourth spring.

Culture. Until recently, the market has demanded blanched asparagus. This is more profitable to grow than green because the stalks are larger and less attacked by beetles but inferior in quality to the green. For home use, the latter is generally grown. The difference is due wholly to the method of handling. For green grass, level culture is all that is necessary; for white, ridges of soil 18 to 24 inches high are thrown over the crowns by special implements so the shoots have to grow long before they reach the light. As soon as a shoot pokes through the soil, it is cut with a special knife at the end of a long handle. This work is done daily through the cutting season, which should end as soon as green peas are ready for use from the same garden. Green asparagus is cut an inch or more below ground or "snapped off" which, for home use, insures the best quality. To do it, push the finger into the soil beside the stem which is then bent across until it snaps. An early crop can be had by lifting strong plants in late winter and forcing them indoors like rhubarb, after which they are discarded. For market, the stalks are washed and placed in a special "buncher" with the tips all one way; each bunch is tied with tape, and the butts are sliced off square.

FIG. 459. Asparagus plant showing shoots just at the edible stage.

BEAN. As grown in gardens, beans are classed popularly as bush, or pole. Most of these are included in 2 species—Kidney or Haricot, and Lima or Sugar. The Broad or Windsor is grown to a considerable extent in gardens in Canada but not in the United States, as it requires a long, cool summer. The other groups, Dolichos, Yard-long, Asparagus, or Hyacinth; Soy or Soja; Scarlet Runner; Velvet or Banana; and cowpea, are unimportant in this connection, or are grown as field crops and are treated in Chapter 26. All are tender and succeed best in warm weather and sunny exposures.

Types. Garden beans are wax—or butter—podded and green-podded. They are used as string or snap beans while immature; when fully grown but unripe, as shell beans, and when ripe the seeds are used for culinary purposes. The earlier beans are usually of the bush type. Lima beans are always used as shell beans, or when ripened, as dry beans. They are made up of two distinct types, the Sieva, or Carolina, type, a smaller, earlier bean, and the larger types, the flat, large-seeded, and the potato Lima. The bush Limas have a tendency to revert to the pole type.

Soil. Moderately fertile, thoroughly drained soil is necessary to succeed in bean growing. For early crops, sandy loams are best, especially for Limas. Gravelly soils must be kept well supplied with vegetable matter. Clay loams, especially limestone soils, are best for late crops and dry beans. Mucks are not satisfactory because they produce too much vine and too few pods. Where possible, beans should be rotated with other crops although they will often do well for years on the same ground. In garden and trucking practice, an early crop such as spinach, lettuce or radishes may precede beans, which must not be sown until the soil is warm and danger of frost has passed.

Fertilizing. Too much nitrogen, as from commercial fertilizers and fresh stable manure, is undesirable because it makes vines instead of pods. Late beans have a longer season than do early beans to secure their nitrogen from the air. For early crops, commercial fertilizers may contain 4 per cent of nitrogen; for late, rarely more than 2 per cent, often none. From 10 to 20 tons to the acre of well-rotted stable manure are often supplemented by 500 or 600 pounds of a commercial fertilizer analyzing 8 to 12 per cent each of potash and phosphoric acid. Usually the manure is plowed under, or if fine, disked in after plowing; drill or broadcast the fertilizer after 1 or 2 harrowings of land plowed the previous fall or in early spring. Often the fertilizer is

drilled beside the rows of beans. For pole beans, applications are often made to the hills. Good clean tillage is all that is required. Beans must not be worked when the vines are wet from rain or dew. The pole beans will need tying to the poles at intervals as they grow.

Planting. Though there is risk of loss by frost, it is often a good plan to make an early sowing followed at intervals of a week by other sowings. For hand and wheel-hoe tillage, rows of bush beans may be 15 to 18 inches apart, for horse, 27 to 36 inches. The plants should stand singly 4 to 6 inches apart, or in hills of 2 or 3, 15 or 18 inches apart. The latter is the better plan in heavy soils because the beans can push through the soil easier. If planted in drills, pole beans should be no thicker in the rows, but the rows 3 or 4 feet apart. If in hills, 3 or 4 plants in a hill, and the hills 4 feet apart. Dwarf Limas are managed the same as bush beans; pole Limas like other climbing beans, except that they must not be sown until the soil has become well warmed. Sometimes they are started indoors in pots and transplanted, but this is of doubtful advantage. It is common practice to set the poles firmly in the centre of the hills, mix well-rotted manure or commercial fertilizer thoroughly with the soil, mounding the latter slightly about the poles and plant the seeds singly by pushing them into the soil about the pole. "Eyes down," is the rule of some.

Harvesting. This is simple as they are picked by hand when they reach the desired stage for "snaps," or "shells," or pickles or for canning. If any are left to ripen, these may be gathered by hand, or the vines pulled and kept in a dry place till threshed.

BROCCOLI resembles cauliflower but requires a longer period of cool weather in which to develop, and in consequence is not grown so much in America as it is in Europe, where it is planted in autumn for spring heading. Moreover the American winter is generally too cold.

CELERY is one of the most popular salad and flavoring vegetables, and is used also to some extent as a cooked vegetable. The plant is really a biennial but is grown as an annual. Selection and breeding have developed many varieties, most of which have stalks which turn white or pink when blanched; others having thickened roots are called turnip-rooted celery or celeriac. Among the green-stemmed kinds are *Giant Pascal, Winter Queen, French Success,* and *Boston Market,* the last a dwarf kind of specially fine table quality. The self-blanching sorts, introduced in 1884, now constitute about 90 per cent of the celery grown commercially. Strong points in their favor are easy blanching with boards or by closer planting; objections are loss of vigor, greater susceptibility to disease, lower quality. The leading varieties of this group are *White Plume, Golden Self-Blanching, Rose-ribbed Self-Blanching.*

Culture. Celery does well on any good loam rich in vegetable matter, and capable of retaining moisture well, or easily irrigated. Commercial plantings are largely upon well-drained "muck beds," and such soils should be given preference on farms. While the plant is water-loving, drainage is necessary to get rid of any excess and thus help to warm the soil. Before a good crop can be expected, marshy land must be given two or more years of preparatory cultivation besides mere clearing of trees and brush, because water-logged land is often sterile for several years after drainage. In the early years of cropping such soils, stable manure gives far better results than commercial fertilizers; liberal dressings of lime are usually helpful. Plowing should be fully 10 inches deep and subsoiling another 6 or 8 inches deeper, for the deeper the feeding area the better. Fall plowing is specially helpful if the furrows are left rough until spring. Garden soils should be as deeply stirred as possible and lavishly enriched with well-rotted stable manure (30 to 50 tons to the acre). Hen and pigeon manures are excellent, also, especially in the rows. As the seeds are very small and slow to sprout, and the seedlings tiny and easily choked, it is best to sow thinly and shallow in finely prepared rich soil in a protected bed or a flat. Sprouting may be hastened by keeping the seed damp for a day or two before sowing. The bed and the seed must not be allowed to dry, or the seed or plantlets will be checked and inferior.

In all methods of growing this crop, the plants must be well cultivated from start to finish. Wheel-hoes are useful while the plants

FIG. 460. A planting board for use in planting seedlings in flats. Thrust a stick through each hole, remove the board and set a plant in each of the evenly spaced depressions

are little and in small plantations; special celery cultivators later and in large fields. For the home garden, ordinary hoes will answer.

Transplanting. When an inch high, the seedlings must be transplanted 1 inch asunder in rows 2 inches apart to secure first-class roots. Final transplanting to the field is done when the plants are 4 to 6 inches tall. The distances to set them there depend on the method of growing. In the narrow-row method, adapted to early crops and small areas, they are set 6 inches apart in single rows, or alternately, 6 or 8 inches apart, in double rows with spaces 3 feet between the double or single rows. Boards are used for blanching. In the broad-row method used for fall crops and earth blanching, the distance between rows is 5 or 6 feet, the plants being set in either single or double rows. In the "new celery culture," the plants are set 8 or 10 inches apart each way in beds 6 to 12 or 15 feet wide, with a path separating each pair of beds. When the plants begin to shade the soil, the bed is surrounded by a board frame a foot high. This compels the plants to grow tall and to blanch themselves. By this method, much space is saved and practically as good celery is produced as by the other methods.

FIG. 461. Blanching celery by placing a drain tile over it

Blanching is due to depriving the leaf-stalks of light. The leaves grow naturally, but the stalks become white, tender, less stringy and better flavored than if green. Blanching is brought about by several methods besides close planting as discussed above, as by excluding light artificially by (a) boards, (b) tiles, (c) paper, and (d) earth. *Boards.* In the North and in Florida, old pine or cypress boards 1 foot wide and 1 inch thick are laid flat on the ground on each side of the rows, the edges being close to the plants. By raising the outer edge, a man at each end, the leaf stalks are raised. The boards are fastened at the top by heavy wire double hooks. *White Plume* and *Golden Self-Blanching* are most popular for this method, because they do not stand earthing very well, but celery so blanched is not so good as that earth-blanched. New lumber is liable to taint the celery. *Manila paper cylinders* and 4-, 5-, or 6-inch *drain tiles* are used in a small way; but the former takes too much labor to adjust, and the latter are too cumbersome and heavy, yet give better quality celery than that blanched by boards or paper. Untarred building paper rolls 3 feet wide may be sawed to give three strips a foot wide to place like boards beside the rows. It is lighter and cheaper than boards and properly handled, should serve for 2 or even 3 crops. Roofing manufacturers offer specially prepared, tough paper in 12-inch-wide rolls for blanching purposes. *Earth blanching,* the popular method for late celery, gives highest quality but, though inexpensive as to material, requires much labor and yields smaller quantities in a given area because the rows are far apart. Dwarf kinds are planted 4 feet apart; giant ones 6 or more. Until the plants are ready to blanch, all cultivation is level. In a small way, the plants may be earthed by hand, the loosened soil being brought up to them little by little at intervals of a week or two; in a large way, wing-toothed cultivators are used at first and either a double moldboard hiller or an asparagus ridger used later. In the former, two men can work to better advantage than one alone. The first man standing astride the row gathers the stalks into an erect bunch while the second throws loose earth against the plant. When one man works alone, it is an advantage to use a strong cord tied to a stake above end of the row, to wind it around the bunched stalks and proceed thus from plant to plant to the other end of the row where the cord is tied to another stake. Then the earthing can be done. It will be a help to have the cord in a ball held in a string-holder fastened to the right arm so it will easily work down to the thumb and finger.

Harvesting and storing. The method of harvesting celery depends on the method of growing and blanching followed. A spading fork or a potato hook will answer for that blanched with paper, tiles or boards, and to be used immediately. The coarse outer stalks are removed, the roots cut off preferably with four slashes that leave the crown pyramid shaped; the heads washed, rinsed, drained, and, if for sale, tied in bunches of a dozen. When earth blanched, the plow throws a furrow away from each side of the ridge, a second furrow on one side close to the row exposes the plants which are bent and pulled toward this side of the row. Such plants may be trimmed as described, or stored.

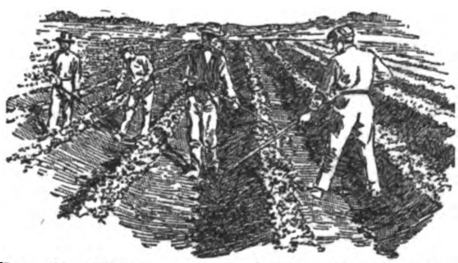


FIG. 462. Hilling up celery for blanching on a large truck farm


FIG. 463. To store celery in the cellar, stack it closely in the corner packing the roots with sand.

In cold climates, celery is often stored in pits or temporary sheds made from the blanching boards. For home use, the soil is often ridged up until the tops are almost covered. The ridges are then covered with litter held in place by boards or soil. When cold weather approaches, 4 to 6 inches of manure is added. This method keeps the plants fairly well but does not favor getting them when the ground is frozen. A root cellar is better. The plants dug with their roots are set close together in sand or soil which may be watered from below so as not to wet the leaves or stalks. Boards set against the plants will exclude light and favor blanching. Coldframes and hotbeds may be used instead of cellars. Sash and mats are not necessary except in coldest weather, but the plants should be kept dark and not too warm. Commercial growers have specially constructed celery storage houses. Others send direct from the field to the city cold storage.

CHIVES or CIVES. A little onion-like plant hardy and perennial that forms dense tufts. The leaves are sheared off and used for flavoring in salads, etc. New foliage develops rapidly. To start a bed, plant small clumps in early spring 12 inches apart each way or in rows, and cultivate to keep clean of weeds. Later the plants may be increased by dividing and transplanting like rhubarb.

EGGPLANT. The name refers to the shape of the fruit. An erect, stocky, branching supposedly East Indian annual plant the fruits being used when half ripe, fried and less commonly baked and served as a vegetable. In the United States, it is grown commercially as far north as New Jersey and Long Island, but in cooler sections farther north and west, only in home gardens, since it is quite tender and requires a long, warm season. The large, attractive purple flowers are followed by blue, black or white fruits varying in size at maturity from that of a hen's egg to that of a man's head. Some of the best known varieties are *New York Improved*, *Black Beauty*, *Black Pekin*, *Early Long Purple*, and *Ivory*. Cool nights and short summers make good yields doubtful in the North. Warm sandy soil, rich and well drained, and a southern exposure give best results, but the plants must be started under glass even earlier than tomatoes, and never allowed to suffer a check. They should be 6 or 8 inches high at least before being set out. It is a good plan to grow the plants to this stage in 3- or 4-inch flower pots, or heavy paper pots made for this purpose. In the home garden, they should be set 2 to 4 feet apart in rows 3½ to 4 feet apart, the spacing depending largely on the size of the variety which can be learned from catalogues and seedsmen. The purple and black varieties should be well colored. Mature fruits are tough, seedy and lack flavor. Eggplant is troubled by the same insects that attack potatoes. Fungous diseases, though seldom troublesome, may be controlled with bordeaux mixture.

GARLIC. A perennial, onion-like plant of which the compound, strongly-flavored bulbs—called "cloves" and resembling a multiplier onion (p. 384) are very popular with South Europeans, for flavoring soups, stews, salads, etc., but much less so with Americans. The cloves are generally used for planting; the soil, requirements and cultural details being the same as for onions grown from sets. Plant the cloves in midspring, 4 inches apart, 1 inch deep, in rows 12 to 15 inches apart. Harvest when the tops die, braiding the leaves together and hanging the clusters of bulbs in a dry, airy place.

LEEK. A hardy biennial grown as an annual for its thickened stem and leaf bases having a mild onion-like flavor, and which well blanched, are used for flavoring soups, stews and salads, or boiled and served with a butter or white sauce. Any soil suited to onions will grow leeks. Seed may be sown in a hotbed for an early, transplanted crop, but usually it is sown out of doors when the earliest radishes are sown—often with radish as markers (p. 180). Drills may be 15 or


FIG. 464. An eggplant with some leaves removed and the stems held up to show the fruits

18 inches apart; seed should be sown 4 or 5 to the inch and covered ½ to 1 inch; thin seedlings to 6 inches apart. Blanching is essential for best flavor. Some growers sow the seed in trenches 4 to 6 inches deep and gradually fill up with soil after thinning; others sow as they do onion seed, on the level, but gradually work soil up around the plants till a 6-or 8-inch ridge is formed; others combine both methods. Vigorous growth encouraged by plenty of soil moisture in the fall, favors high quality. Leeks being hardy may be left till late before digging. For winter use they may be stored like celery in moist soil in a root cellar.

LUFFA, vegetable Sponge or Dish-cloth Gourds, are grown like cucumbers (but usually on a wall or trellis) for the fiber of the fruit which can be used in place of a sponge or dishrag. The fruit is allowed to mature and the pulp is worked off in water.

MARTYNIA. A coarse-growing annual herb with handsome flowers and hooked fruits, used while green for pickling. Plants are started indoors and transplanted like tomatoes, 4 by 4 feet apart. They do best in a hot, sunny situation.

MUSHROOM. The familiar "buttons" or "caps" which are gathered and used are really the fruiting bodies of a fungus consisting of an underground mass of fine white threads. Delicate in flavor and texture, mushrooms are considered a great delicacy when stewed, broiled, made into sauces, etc. Because of the difficulty of raising them, mushrooms usually bring high prices in city markets, and often prove highly profitable for the successful grower. This fact has led many people who want to make money fast, to attempt this crop, often with disappointing or even disastrous results, for not every location is suitable and not every one can succeed, even where all conditions seem favorable. The only way to start is in a small, experimental way with full knowledge that failure is quite probable. Any one getting past this elementary stage and planning to grow mushrooms for market, should obtain Duggar's "Mushroom Growing," the standard authority on the subject.

Propagating. Mushrooms are propagated from "spawn" which consists of the *mycelium* or underground parts, developed by special methods in a mixture of manure and earth and sold dry in the form of bricks (English spawn) or loose and strawy (French spawn). Formerly this was entirely imported from Europe, but now it is being made in America. Many people obtain a home supply of mushrooms of various kinds from the fields, but for market purposes, commercial spawn should be used for the sake of uniformity of yield and quality.

Culture. Since mushrooms have no green parts they do not need light, and may be grown in dark places. Hence caves, mines, cellars, and under greenhouse benches where temperature and moisture can be controlled but where most crops would not develop, space is profitably utilized. Naturally mushrooms grow in pastures and lawns,

The best temperature for mushroom growing is between 60 and 70 degrees F., though slight variation above or below these limits is permissible. Start a bed between September and January. Thoroughly mix together fresh horse droppings free from straw, etc., and fresh fibrous loam—preferably rotted sod from an old pasture—or medium light soil, at the rate of 3 loads to 1, and pile up. Turn every day or two until the violent heat begins to fail, then spread a layer 4 feet wide and as long as desired, on the ground or shelves in the place chosen for the bed. Pack firmly

FIG. 465. A good crop of mushrooms in a small, home-made bed

with a brick or wooden block, then add layer after layer, firmly packing down each until the bed is 8 or 10 inches thick. Now plunge a thermometer into the soil and when the temperature falls below 90 degrees (but before it reaches 75) plant the spawn by making holes with a hoe handle or dibble about 2 inches deep, a foot apart all over the bed, and dropping into each hole a piece of spawn about the size of a small egg. Then fill the holes with the soil and manure mixture packed tightly, beat down the whole surface, add a 2-inch layer of sifted loam and pack down firmly.

If the place is light, 4 to 6 inches of straw may be spread on the bed. If the soil is reasonably damp, no watering is necessary; otherwise spray—or sprinkle with a fine rose watering can, until moist, *not wet.* A tablespoonful of nitrate of soda or saltpeter in a pail of water will lengthen the bearing season of the bed.

Harvesting. If conditions are right (temperature and moisture remaining steady) the buttons should appear in 5 to 8 weeks, and harvesting may begin when they are ¾ to 1 inch in diameter. Cultivated mushrooms are usually gathered before the "cap" expands enough to break the "veil" underneath which joins it to the stem. Twist off the buttons rather than pull them out, and fill up

with loam any holes made in harvesting, to protect the growth below. A bed should continue in bearing for several weeks, an average total yield being estimated at ½ to 1 pound per square foot. For market, the crop is usually packed in grape or other baskets and sold by the pound.

OKRA or GUMBO. A tropical African perennial cultivated in temperate climates as an annual for its young tender pods which are sometimes cooked and served whole, either hot with a cream sauce, or cold with mayonnaise, but most often sliced in soups and stews. The 50 or more varieties listed in America are of 3 general types; namely (1) *Tall Green Long Pod, Tall Green Short Pod;* (2) *Dwarf Green Short Pod, Dwarf Green Long Pod;* (3) *Lady Finger White Pod, Lady Finger Green Pod.* While all of these are grown largely in the South, the dwarf, quicker-growing kinds are best in the North. Where the seasons are short, plants should be started under glass 4 to 6 weeks before setting out in the garden at the same time as tomatoes. Where the season is long, the seed may be sown directly in the garden. Plants should stand 1 foot apart in rows 3 to 5 feet apart and be cultivated like corn. As soon as pods begin to form, go over the plants daily, picking all pods while they are small, soft and stringless. They are best used fresh but may be canned or sliced, strung on cords and dried in a warm, airy place for winter use.

ONION. A biennial or perennial bulbous plant related to the lily. There are 3 classes or types: (1) *seed onions* which are grown from black seeds and which produce the bulk of the commercial crop; (2) *multipliers*, which rarely develop seeds but form small bulblets around the parent bulb; the hardy, so-called "potato onion" which, if mulched, withstands northern winters, belongs to this group; and (3) *top* ("Egyptian") onions which in place of seeds form clusters of small bulbs at the tops of the flower stems. The chief advantage of the last two types is earliness, but the quality is inferior to that of the first group. The small bulbs are planted usually to produce crops of "bunch" or "spring" onions or "scallions," but they must not be confused with true onion "sets" which are used for the same purpose as well as to save time in growing mature bulbs. True sets are simply small onions of standard varieties grown as described below, stored over winter and planted in early spring. Spring-sown seed gives the same results as sets, and more cheaply, but requires considerably more time. Bulbs from spring-sown seed are better keepers than those grown from sets.

FIG. 466. One type of onion is propagated by seeds borne at the top of a stalk.

Growing sets and bunch onions. The preferred soil is rather poor, light, deep loam. Sow seed thickly (about 200 seeds to the foot), cultivate and weed but do not thin the seedlings, harvest, clean and store the bulbs which will range from ¼ to ¾ of an inch in diameter, like full-sized onions (see below) or mix them with chaff and let them freeze but not thaw until spring. During winter or in early spring, plant sets (or multipliers or top bulbs) in a hotbed, coldframe, or forcing house; and, as soon as the ground can be worked, outdoors. Though not thoroughly hardy, they will stand considerable frost. Placed 2 inches apart, a quart of sets will plant 100 feet of row. For hand or wheel-hoe cultivation, make rows 15 inches apart. While 1 to 2 inches is the usual depth of planting, better stems result if the sets are planted 3 or 4 inches deep, but this requires that the soil be fairly light. Outdoor plantings are generally ready for use in 3 to 4 weeks, and provide a steady supply of scallions until thinnings from the seed-onion rows are ready to eat. Best results with bunch onions call for a rich, loose soil prepared in the fall. Popular varieties for sets are *Yellow Dutch, Silverskin* and *Extra Early Red.*

General crop. While the great commercial onion fields are on muck lands, good home garden crops may be grown on any rich soil if not heavy or poorly drained; but it must be in exceptionally fine condition. Old sod and corn or grain stubble land must be well cultivated at least a year previous to planting onions that there may be not rash to interfere with the bulbs. In the fall, apply well-rotted manure at the rate of a ton to each 4 square rods (40 tons per acre) if possible, plow or spade and leave rough until spring, then harrow finely, finishing with a Meeker or smoothing harrow, or by hand raking. The soil cannot be too fine. A quickly available fertilizer containing about 3 per cent nitrogen as nitrate of soda, 6 per cent phosphoric acid as acid phosphate, and 8 to 10 per cent potash as either muriate or sulphate, if available, should be broadcasted at the rate of 600 to 1,500 pounds per acre, and worked in at this time. Only good, fresh seed should be used; old seed, unless specially handled, is likely to sprout poorly. Where 100 feet or more of drill is to be sown, a hand seeder will be helpful. Drills are usually made 12 to 18 inches apart, and seeds dropped at the rate of about 30 to the foot, being covered from ½ to 1 inch deep depending upon the texture of the soil. An ounce should plant 100 to 150 feet of drill. As onion plants are hard to see when first coming up, a few

radish seeds may be sown with the onion seeds to mark the rows.

The "New Onion Culture." A method often employed when growing Southern types of onions, such as *Prizetaker* and *Gibraltar*, in the North, is to sow the seed thinly in January, February, or March in a forcing house or a hotbed, and transplant the seedlings to the open as soon as the weather has become somewhat settled. By this means these varieties get enough start so that they reach maturity in New York, Ohio, etc. A further distinct advantage is that the risks of loss are less than where the seed is sown out-of-doors; for even where sowing is done very early, a poor stand may result but not be discovered until too late to make a second sowing. In the garden, thinning the seedlings for the table will soon get rid of the excess, so the plants will stand 2 or 3 inches apart in the rows. Transplanted large kinds need 4 to 6 inches. Cultivation in all cases consists in keeping down weeds and maintaining a loose, open soil surface.

Harvesting and storing. Warm, dry autumn weather favors curing onions. When a considerable proportion of the onion tops have fallen, the remaining "thick necks" or "scallions" may have their tops broken down or be pulled for immediate use. When ripe the bulbs are pulled and allowed to dry a day or two on the ground. When dry they may be placed in slat crates and removed to cover. For home use, it is not necessary to cut off or clean the bulbs, but for market the tops are cut about ½ inch above the bulb and the loose stuff removed. Four or 5 bushels to the square rod (600 to 800 bushels an acre) is a good yield. While onions may be kept frozen all winter, they will not stand alternate freezing and thawing. If frozen they must be allowed to thaw very gradually in a moderate temperature, and must not be bruised while thawing. The north side of a barn loft is an excellent place for keeping frozen onions which should be covered with 3 or 4 feet of straw. This is a popular way of storing sets. Mature onions are generally stored in dry, frost-proof buildings, sometimes fire-heated. The home gardener has thus choice of two methods which, however, will not combine.

FIG. 467. The propagative parts of Egyptian "top" onions (*a*), and of the potato or multiplier type (*b*)

Varieties. The globular varieties of onions are most popular in the market mainly because they pack better and therefore suffer the least injury. The flattened varieties are said to be better for home use because they cook more evenly and more quickly than globular ones of equal size. A few varieties are of other shapes. The colors are white, yellow, red and brown, the first generally the mildest, the red the strongest with the others intermediate. Among popular kinds are *Wethersfield Red, Danvers Yellow, Southport White, Southport Yellow, Southport Red, Prizetaker, White Barletta (pickling), and Australian Brown.*

PEA. A hardy, cool-season annual, cultivated generally for its immature seeds which are shelled and boiled. In a few varieties, the green succulent pods are used whole; and to some extent the dried grains of the round-seeded sorts are used for soups. The plant is a vine ranging from a few inches to 6 feet, slightly branching with flowers nearly always white.

Types and varieties. The smooth, round-seeded such as *Alaska*, and *First of All*, are exceptionally early and hardy but of lower quality than the early wrinkled-seeded varieties such as *Gradus, Thomas Laxton, Sutton's Discovery* and *American Wonder*, which cannot be planted quite as early, because the seed rots. Later kinds are mostly taller growing than these but are more productive and of higher quality. Among them are *Telephone, Stratagem, Telegraph*, and *Champion of England.* The third group varieties—all tall-growing—include *Mammoth Great-seeded Sugar, Sugar Sword*, and *Early Sugar* which bear small-seeded pulpy pods which are cooked like beans. For the home table, a few of the round-seeded and the edible-podded varieties may be grown, but the bulk of the crop should be the dwarf wrinkled-seeded kinds with a fair proportion of the tall-growing kind, also wrinkled. The only merit of the round-seeded pea is its hardiness.

Culture. Though peas thrive on a wide variety of soils, they do best in cool, moist, well-drained, sandy loams of moderate fertility—rich soil makes stronger vines but does not increase the yield. Good results come from any loose, friable, properly prepared loam. The heavier soils are more suited to the late sorts because they hold moisture better. For best results, the soil should be deeply plowed, thoroughly harrowed and well enriched with decayed manure, with supplementary commercial fertilizer if needed. Experiments have proved that shallow preparation and planting are mistakes. Fresh stable manure tends to fruitless vines but there is no danger in using rotten manure freely. The best way is to apply manure heavily to a crop the previous year. It is not needed where clover sod, cow-peas or crimson clover

were grown the previous season as cover or green manure crops. While peas can gather nitrogen from the air, early plantings are benefited by dressings of nitrate of soda which becomes available before the peas are able to get the atmospheric nitrogen. In fertilizers used for peas, therefore, there usually is 2 or 3 per cent of nitrogen and 8 to 10 per cent each of phosphoric acid and potash. All vines, after harvest, should be buried to help enrich the soil.

Planting. Peas planted in furrows 6 to 10 inches deep give a larger crop and a longer harvest than when planted 2 to 3 inches deep. This applies especially to the wrinkled, tall-growing late varieties. In such cases, the very deep trenches are not completely filled until the plants are several inches tall. Since the plants are hardy, sowing may be done in earliest spring, to aid which the ground may be plowed the previous fall and left rough until spring. For a long-continued supply, succession sowings may be made or early, mid-season and late varieties sown all at one time. Each plan has good points. In home gardens, 2 drills are made usually 6 inches apart with 24 to 48 inches between pairs of drills, depending upon the size the plants will attain. When the very dwarf kinds show buds or blossoms, sweet corn, cucumbers or tomato or pepper plants may be sown or planted between the rows to occupy the space after the peas have been gathered. While dwarf kinds do not need staking, they give better results when held off the ground by brush or preferably "chicken wire." Tall kinds must be "brushed" or "wired." The best way to manage this is to stretch the wire web on posts say a rod apart and about 6 inches above the ground. The peas soon take hold and cling to the supports. Peas do not endure hot weather. For latest crop, sow early varieties in late July or August.

Fig. 468. Cultivating peas after setting brush for them to climb on. This is better than a wire support

Harvesting. Gathering peas in the home garden is always done by hand because judgment is needed to select the pods of proper development for use. For canneries, the whole plant is passed through a "viner" which thrashes the peas out of the pods. Most people make the mistake of allowing the peas to get too ripe, thereby gaining size and hardness but losing flavor and quality. The peas should fill the pods but still be soft. If to be shipped, they must be placed in well-ventilated packages holding no more than a half barrel, or they may heat and spoil. The best package resembles a "Delaware peach basket" but is taller—as tall as a flour barrel.

PEPPER. A group of tender tropical American herbs and shrubs widely cultivated as annuals for their more or less pungent pods used in salads, pickles, and for flavoring purposes. Varieties differ widely in size, form, color, pungency and other qualities. They are divided into two classes; namely, pungent ones—*Tabasco*, *True Red Chili*, *Bird Eye* or *Creole*, *Hot Bell* and *Long Red Cayenne*; and —*Chinese Giant*, *Bull Nose*, *Neapolitan*, *Golden Queen* and *Ruby King*.

Culture. While the plants are grown and handled like tomatoes (being always started indoors or in a hotbed except in the South) they are somewhat less tender and will stand a rather cooler season and even a little frost; however, best results are obtained in warm sections and seasons. A high temperature is needed to sprout the seed and to secure quick growth of the plants under glass. The soil should be light and loamy, rich in vegetable matter but not too well supplied with nitrogen. Plants should not be set in the field till danger of frost has passed. They may stand 15 to 18 inches asunder in rows 24 to 30 inches apart, according to amount and method of cultivation to be given. The fruits may be used green or allowed to remain on the plants until red (or yellow—in some varieties) or even until fully mature, in which case they are generally dried for winter use.

POTATO. Probably the most widely grown of all food plants throughout the world and, next to the cereals, the most important crop. Native to South America it is universally grown as a staple crop and furnishes a large part of the daily diet of millions of people. The plant is a perennial, forming tubers to carry it through the winter; it is grown as an annual, the tubers being harvested and stored. The tops will not endure frost which is the great limiting fact in its area of cultivation. The plant crops 2 to 3 feet in height making succulent branches and producing white or pale mauve flowers. Under continued cultivation it has almost lost the power to produce seed, but propagation of new seedlings offers a field of possible great

results in producing new types to fit local conditions. The United States produces annually more than 200,000,000 bushels of potatoes. Though the most important of field vegetable crops, it is often omitted from small gardens because of the space it occupies, but early varieties may be used profitably and may even be followed in some localities by early corn. For home use "new potatoes"—immature early tubers—are a real delicacy.

Varieties. The differences in type are very slight. Some make larger growth and are later in maturing; some produce pink tubers, although those of most sorts are yellowish white. For home use, popular early varieties include *Early Rose*, *Early Ohio*, *Beauty of Hebron*, *Irish Cobbler*, for northern gardens; *Irish Cobbler*, *Red Bliss* (*Bliss Triumph*) and *Early Ohio* for southern. Late ones in the North are *Carman*, *Rural New Yorker*, *Green Mountain*, *Burbank*, and *White Giant*. Late varieties as understood in the North are little grown in the South, a second planting of early ones taking their place. In Maryland and Virginia, the dividing line, *McCormick* is popular.

Soil. The nature of the soil is believed to affect the quality more than the quantity of the crop; kind and quantity of fertilizer and seed, character of cultivation and the nature of the climate have the greater influence on the quantity produced. Largest yields in the cooler parts of the continent are secured from moist, fairly rich loams, smallest from light sandy ones. In the latter cases, however, digging before maturity may partly account for the smallness; such potatoes are usually dug before fully ripe, to supply the demand for "new potatoes"; the heavier lands generally produce the late and fully matured, heavier and larger potatoes. Best quality potatoes are grown on rich, sandy loam well supplied with humus. This is partly because such soil offers less obstruction to both roots and tubers, and partly because in such soils there is usually a freer passage upward of water from below. Heavy clays, mucks, peats, thin soils and soils underlaid by rock, hardpan or other impervious strata are generally unfavorable to potatoes.

Newly-plowed clover sod has two distinct advantages: it supplies abundant vegetable matter, thus increasing the water-holding capacity of the soil, and it improves the physical properties of the soil which thus help tuber development.

Planting. For small garden planting, "hills" may be made with a spade; for areas of half an acre or more, furrows are made with a "single-shovel" or "turning" plow and the "seed pieces" are dropped in the bottom. The plow or a corn cultivator may be used to close the furrow and form a ridge over each, the ridges to be harrowed down level 2 or 3 weeks later to kill weeds and leave the surface well stirred about the plants. Distances between pieces vary from 9 to 18 inches, though when planted in checks for cross cultivation, they may be 30 inches each way. In

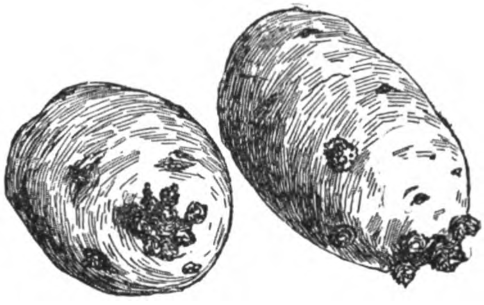


FIG. 469. Potatoes partially sprouted in order to hasten the crop

the former case, and with small-growing early varieties, 27 to 30 inches are usually allowed between rows; 30 to 36 with late ones. The amount of seed needed to plant an acre will vary from 8 to 10 bushels. Depth to cover the seed will vary with the character of the soil from 3 to 4 inches in heavier types, to 4 or 5 in light ones. To prevent freezing of the tops, early planting should be made deeper than later ones which generally escape late frosts. Depth will vary also with the style of cultivation; if to be ridged, it will be shallower than for flat culture.

How to secure earliness. To secure earliness, several things will help. The land may be prepared the previous autumn by growing some crop that requires late tillage, or by fall plowing and leaving the furrows unharrowed until spring. A warm site and an early soil, especially a dark-colored, well-drained soil sloping somewhat to the east or the south, are favorable. If commercial fertilizers are used, the plant food in them should be quickly available. Earliness can be still more hastened by sprouting the seed tubers before planting. Spread the unsprouted tubers on a well-lighted, fairly-warm floor about a month before planting time. Soon the eyes will begin to develop stubby, usually purple or dark green, shoots which, by planting time, may be an inch long. The tubers may then be cut so each piece will contain 1 sturdy shoot. Care is needed to prevent breakage. By this method, a gain of 10 days or 2 weeks has been reported by the Rhode Island Experiment Station as the result of several experiments. When this method is not practised, it is usual to cut the tubers so that each piece has 1 or 2 eyes. The larger the piece the better, because it thus furnishes more reserve food if wanted; develops stronger sprouts and other conditions being equal, a better crop than do small

pieces or pieces with many eyes. In this last case, many sprouts may result in spindling growth, "small potatoes and few in a hill." It is best not to cut the tubers more than a day or two before planting unless the cut surfaces are liberally sprinkled with land plaster (gypsum).

FIG. 470. In making a furrow with a hoe, stand on the guide line to keep it straight.

Cultivation. Plowing before planting should be deep and thorough, preferably in the fall if the land is at all heavy; if in the spring, then before the clover has grown very much, the idea being to prevent getting fermenting material near the seed. Early plowing allows considerable decay before planting. Harrowing should follow plowing immediately. It should compact the lower soil but leave the surface 3 to 5 inches loose for the seed-bed. The first harrowing may be with a disc or a spring-tooth, later ones with an Acme. Two or 3 harrowings may occur before planting, and 1 or 2 after to keep the surface loose and to kill weeds. The last may be given just as the first sprouts appear. Though some of these may be injured, the loss will be more than offset by the reduction of weeds and the saving of moisture.

Repeated experiments by practical growers and investigators have proved that, with late potatoes, flat or level tillage gives better results than does hilling or ridging, except where the soil is wet or shallow—conditions in themselves unfavorable to this crop. In flat culture, less soil surface is exposed to the drying action of sun and wind, hence more moisture is saved for the crop. Slight ridging at the last cultivation may be an advantage when the tubers are in danger of exposure to the sun, in which case they would turn green and be of inferior quality. With early potatoes, hilling or ridging are not so objectionable, as the crop is generally ready to harvest before it would suffer from summer drought. For level culture, a 5-tooth cultivator and the 2-horse corn cultivator fitted with narrow blades are very popular. In no case should the teeth be wider than 2 inches —1½ is better—so the ground may be left as smooth as possible. For ridging, a narrow shovel plow will answer the purpose. The important point in all cultivating is less to kill weeds than to keep the surface loose and to prevent the formation of a crust. Hence it should be done after every rain, and once in 10 days or 2 weeks in clear weather.

In some localities no tillage is given after planting unless a hard rain packs the surface. Instead, straw is spread 4 or 5 inches deep over the whole field. When this plan is followed, the crop is planted as early as possible, and the straw applied just when the first shoots appear, sometimes earlier. By this plan, moisture is saved, weeds prevented, and the tubers protected from the sun. The crop is never dug for "new potatoes," but allowed to mature. Potatoes so grown are considered of superior eating quality, therefore command higher prices than those produced by ordinary methods.

Fertilizing. If not already well supplied with potash, this plant food should be supplied. When given in commercial form, the sulphate (high-grade only) should be preferred to the muriate because this produces better results. Potato fertilizers usually contain 3 to 4 per cent nitrogen mostly in the form of dried blood, sulphate of ammonia or nitrate of soda; 6 to 10 per cent available phosphoric acid mostly in the form of acid phosphate; and 8 to 10 per cent potash mostly and preferably as high-grade sulphate. The amount to apply varies from 500 to 1,200 pounds per acre. For economy's sak , the nitrogen needed by potatoes should be secured from leguminous cover crops or green manures which, preferably, should be fertilized liberally with mixtures rich in potash and phosphoric acid. Stable manure and lime are undesirable as direct fertilizers because they favor certain diseases, especially scab, of the tubers. When used, manure should either be thoroughly decayed, applied as a top dressing to a sod or green cover crop before plowing, or if fresh, used to grow cover crops, or on a clover sod preferably after the second cutting. Scattering manure in fall or early winter on sod is a good plan to precede spring plowing. Applying just before spring plowing is not advisable, neither is working it in with a disc or other harrow. Applications of manure to previous crops may run to 50 or 60 tons an acre.

Harvesting and storing. Yields average about 95 bushels to the acre, but by good tillage 200 to 300 or even more may be secured. In harvesting small garden areas, as in planting and caring for them, only hand tools are needed. The spading fork and the potato hook are most popular. The former has 4 or 5 broad long tines set in extension of the handle; the latter has round or flat tines bent at right angles to the handle. It is used like a hoe. The fork is best in heavy soils, the hook in light ones. Areas of an acre or so may be dug with the turning plow run beneath the rows so the tubers are thrown out by the *moldboard*. The plan is not good, since many potatoes are cut or bruised and many are buried. For large acreage a regular "potato digger" is useful.

Potatoes may be stored in "pits" or in cellars. The pits, placed preferably on well-drained knolls, are 6 to 10 inches deep, 4 to 6 feet wide and as long as may be necessary. The tubers are heaped as high as they can be piled without rolling or reaching beyond the edges. Then they are covered with rye or wheat straw 4 to 6 inches thick, and next a layer of earth, 3 or 4 inches deep at first, but doubled at the approach of winter. In cold climates, coarse stable litter or bundles of corn fodder may be used as additional protection. At first, the apex of the heap should be left open for ventilation, but closed at the arrival of cold weather. The root cellar must be without heat, but frostproof and well-ventilated. It may be a separate building or under a barn or other outbuilding. The house cellar will not answer unless without heat, as from a furnace. In the cellars, the potatoes may be stored in bulk or in bins. It is important that there be plenty of windows so that the temperature may be lowered at night especially in spring, thus keeping the tubers dormant as late as possible. At no time should tubers be allowed to freeze. If the range of temperature can be kept below 45 and above 35 degrees F. from autumn until planting time, or until the tubers are used, best results will be secured.

In the South, the difficulty of keeping potatoes from the spring crop to the fall crop may be overcome by digging on cloudy days so as to avoid injury by the sun, or by removing as soon as dug to the shade. Covering with burlap is nearly as good. As the tubers left in the ground keep better than in houses during hot weather, some growers cover thin layers of potatoes with 6 or 7 inches of earth in the shade of a building. This plan gives better results than summer storage in a cellar or under leaves or straw beneath trees.

POTATO, SWEET. A leading crop of the southern states, but cultivated extensively in the coastal plain sections of the Atlantic states as far north as New Jersey. In a small way, it is also cultivated on similar land on Long Island, and in favored spots even farther north. In these places, it is more difficult to handle because of the short season. The yields are also much smaller than from New Jersey southward. Except as a home-garden crop, it has no place in this northern area.

Though more than 100 names are used, only about 25 varieties are distinct enough to deserve names. In the northern fields, *Yellow Jersey*, and *Big-Stem Jersey*, both mealy sorts are leaders; in the South, *Triumph*, *Nancy Hall*, and *Dooley Yam*, all soft-fleshed, watery and sugary, are most popular. The former are typical of the so-called "sweet potatoes," the latter of the "yams," but properly both are sweet potatoes. True yams belong to a different family of plants and are not cultivated commercially in the United States.

Soil. A rich sandy loam is the ideal, as the sweet potato is a gross feeder, while demanding perfect drainage. On heavy and poorly drained soils the roots are long and watery, the yields smaller and the potatoes of inferior quality. When possible a clover sod or a stubble field should be plowed and thoroughly harrowed in late March or early April in the latitude of the Delaware Peninsula; earlier farther south. Each week it should be disked until planting time. Ten days before planting drill in high-grade commercial fertilizer, carrying 3 per cent nitrogen, 6 per cent phosphoric acid and 10 to 12 per cent potash. From 600 to 1,500 pounds per acre is the range, 1,000 being the average.

Culture. After fertilizing, furrows 4 feet apart and 4 to 6 inches deep are made with a one-horse turning plow. Well-rotted stable manure is then scattered in the row and covered with a back-furrow from each side, thus forming a low, flattish ridge. In the ridges at intervals of about 15 inches, the sets are placed with a bricklayer's trowel. To keep down weeds, cultivation is necessary. When the vines begin to run, they are lifted often to prevent their taking root, and to permit longer cultivation. When they begin to fill the hollows between the ridges, the crop is "laid by".

Propagating. For small areas, it will not pay the gardener to grow his own slips unless he already has a greenhouse or a hot-bed. Slips, as rooted cuttings are called, may be cheaply procured from the larger growers anywhere in commercial areas. Where such are not available, however, or where the grower wishes to grow his own, small or medium-sized sweet potatoes may be laid, so they do not touch each other, on the soil of a half-spent hotbed, or in the South in a coldframe. Late March or early April is the time to do this in the Delaware Peninsula; earlier farther south. The tubers are covered with 2 or 3 inches of light soil well firmed and enough ventilation given to prevent decay. In 10 days to 2 weeks they begin to appear. Should the bed become dry it is watered. When the sprouts are 6 inches long they may be separated for planting. To separate them properly, each sprout is grasped with one hand the fingers of which break it from the potato which is kept in place by the other hand. As many roots as possible should be saved. If the "mother" potatoes are not disturbed, other shoots will grow so that 2 or 3 late pullings may be made.

Harvesting and storing. The crop must be gathered before frost injures the vines. In a small way, sweet potatoes may be dug with a spading fork or a potato hook; in a larger one, with a plow from which the moldboard has been removed. But these are less convenient than the special diggers one of which should

soon pay for itself where areas of an acre or more are grown. In any case, the potatoes are merely loosened so they may be pulled by hand. Entire hills are pulled by pulling the stem to which the tubers cling. After lying on the ground a few hours to dry, the potatoes are separated from the vines and removed from the field preferably in slat crates. Careful handling is required as bruises favor decay. To save time and re-sorting, the edible sizes should be kept separate, placed by themselves in 1 or 2 grades, the smaller sizes for "seed" and the "strings" either left with the vines or hauled to a barnyard for stock feed. This is perhaps the most difficult to store of all root crops. Commonly sweet potatoes are placed in slatted bins in outbuildings partly below or wholly above ground. Banked buildings and cellars are believed to give better results. In any case, a space of 15 to 18 inches must be allowed between the backs of the bins and the outside walls which should be frost-proof. Ice-house wall construction is good. While the potatoes are coming from the field, a fire is kept going to dry them well. Coal and kerosene are popular fuels. A temperature of 85 to 90 degrees is generally favored, the doors and ventilators being opened more or less to let the moisture out. In 10 days to 2 weeks, the temperature may be slowly lowered to 55 degrees. If not disturbed and if the temperature is not allowed to get too low, "sweets" may be kept until planting time. In a small way, the potatoes may be stored in layers of dry sand in barrels or boxes kept in a dry, warm room.

RHUBARB or PIE-PLANT. A perennial herb grown for its thick leaf-stalks which, stewed, are used for making pies and preserves. While it is easily propagated by seeds, best results are secured by dividing good plants, because seedlings are variable. The so-called varieties are much alike. For good rhubarb, the soil cannot be too rich or too deeply stirred at the start—18 to 36 inches. Starting with an old clump, pieces may be cut off each with an "eye" or bud and set so the crown that will develop may not be more than 3 inches below the surface, but the root extend downward its full length. In large plantations, the plants should be 2 to 3 feet asunder in rows 4 to 6 feet apart for horse cultivation; but for home use, they may be placed on the south side of a wall or a tight board fence so as to develop early in spring. If the roots are to be forced, they may be placed half these distances apart. Early growth may be induced by heaping manure on the crown, or by protecting by an inverted barrel or box filled with litter. Every year, manure may be lavished upon the plants; they will respond to liberality.

Cultivating. The first year, the rows must be cultivated and kept free from weeds but no stalks should be pulled. The second year, a few stalks may be pulled, but the plants are likely to suffer if many are removed. The third year, liberal pulling may begin. With proper care and liberal manuring, it should continue 10 to 20 years. No cultivation should be done until after the pulling season has closed, and all cultivation after the first season should be shallow so as not to injure the roots. Manure may be applied in the fall as a mulch or—rotted manure—after the pulling season. Never let any blossom stalk develop as it will drain the plant which bears it and thus reduce the crop of stalks the following year.

Early Crop. Early rhubarb is in most demand, at home and in the market. In a small way, barrels, boxes, large flower pots inverted over the plants and surrounded with fresh horse manure are popular as forcers; stalks may thus be had 2 or 3 weeks earlier than those produced by the rest of the plants. Hot-bed sash and frames are sometimes used also, but these are adapted only to home and small local market demands. Forcing has replaced these methods. Roots grown for this purpose are dug in late fall and treated in two ways: (1) Packed closely in greenhouses, the interspaces filled with earth and the whole mass allowed to freeze until a few weeks before the stalks are needed, when heat is supplied by steam or hot-water pipes placed above them or at the side, not beneath. In 5 or 6 weeks, the stalks will be ready for pulling. (2) The roots—only strong ones—are plowed out and allowed to freeze or are frozen in a cold-storage plant, then placed in a basement or cellar where the temperature can be kept at 40 to 45 degrees. Stalks so produced have very small leaves. While they are not quite so good as those produced by the first method, they are more easily secured by any one who wants to do the small amount of work. Much of the rhubarb placed on the early winter market is grown thus. No light is needed in this plan.

FIG. 471. Setting out a row of rhubarb plants

Pulling. In order not to injure the crowns of the plants the stalks are pulled sidewise so as to tear them loose close to the crown itself. If the stalks are to be sent to the market, the leaf part should be cut off close to its union with the stalk: this will delay the stalks from becoming flabby.

SEAKALE. A hardy perennial herb grown extensively in England, and becoming slowly popular in the American home garden. Its young blanched shoots, or rather leaf-stalks, are served in spring as a boiled vegetable

with a cream sauce like asparagus. It is started from cuttings set where the plants are to remain or from seeds in a hotbed, the seedlings being transplanted into a rich deep moist soil. Such treatment gives strong plants in 3 or 4 years. Rows should be 3½ feet apart and the young plants 18 to 21 inches asunder. Clean cultivation is necessary as is the nipping of seed stalks as soon as they start to favor strong growth. In the fall, the dead leaves are cleared away and the plant crowns mulched heavily 4 to 6 inches deep with manure. In early spring, this is removed and the surface raked smooth, care being taken not to injure the crowns which are then covered with sand, moss, or loose compost to blanch the sprouts; or they are covered with large flower pots in which the drainage holes are plugged; or strong plants may be dug up and forced indoors like rhubarb. When the new shoots are 3 or 4 inches long and white they are carefully cut for use. After 3 to 6 weeks of cutting, the sand, soil or pots must be removed so the plants may develop. Management the second and later seasons is the same as during the first.

SHALLOT. An onion-like plant grown for its mild-flavored, gray, oblong bulbs and leaves, both of which are used for flavoring. The plant is managed like garlic (p. 382), although, being hardy, it may be planted in the fall. Ordinarily early spring planting is practised. In the South, young plants are pulled and marketed like bunch onions, during the winter. If allowed to mature, several bulbs or sets develop around each one planted.

SWEET CORN. An important class of corn varieties which contain more sugar and protein and less starch than most field corns. Though extensively grown in southern Canada and the northern states, sweet corn is less popular in the states south of the Carolinas. According to the 1910 census, about 7½ million cases of canned corn were put up in a year, the leading states being Illinois, Iowa, Ohio, Maine, Maryland, New York, Indiana, Wisconsin, Minnesota, and Nebraska, all Northern.

Varieties. Among the countless varieties, the following are widely popular: Early—*Adams Early* (not a true sweet corn but of better quality than ordinary field corn. Valuable because hardy and early. May be planted a week or more before true sweet varieties), *Golden Bantam* (a representative of the yellow sweet corns, which are of especially fine quality, and specially desirable for home use. Its yellow color is against it—until after the first mouthful), *White Cob Cory*, *Red Cob Cory*, *Fordhook*, *Crosby*, *Stabler*, *Minnesota*, *Sheffield*. Mid season: *Sweet Orange*, *Kendal Giant*, *Cosmopolitan*. Late: *Stowell's Evergreen* and *Country Gentleman*. Instead of planting midseason and late varieties, many home gardeners prefer to plant one early kind at intervals of a week or 10 days until midsummer or even later, if there is likelihood of getting edible ears before frost.

Climatic influences. In general the handling of this crop closely resembles that of field corn (p.213), but sweet corn may be grown over much the wider territory because its ears are gathered while immature. Like field corn, the height of the stalk and the time of maturity are influenced by climatic conditions, so that local strains may be easily developed. These do better locally than do equally good strains of the same variety from other sections. Eastern gardeners and canners object to western-grown seed because of differences in quality due to the climatic conditions under which the seed matures. These differences are more noticeable in early than in late varieties. The length of time an ear continues in prime condition for the table depends partly on the variety, partly on the strain, but mainly upon the character of weather during the earing period. Often a few hours of dry, hot wind will alter the texture and flavor very greatly; whereas moist, cloudy or cool weather may maintain the prime condition for 3 to 6 days.

FIG. 472. Sweet corn can be started indoors to hasten its growth and to protect it from enemies.

To have choicest corn, it is advisable to gather the ears within an hour of serving them on the table. Experiments have proved that 50 per cent of the sugar in corn is changed to other substances within 4 hours of gathering. This is why city dwellers complain of poorly flavored corn. For home canning and drying, the same rule holds. Home-dried corn should be a staple because it is superior even to home-canned corn though it has not become popular in the market because of its dark color.

Culture. Sweet corn is more adaptable to soils than is field corn. While a warm loam is desirable, the crop will grow on almost any well-drained soil. For early varieties, the quickest, best-drained areas should be given preference; and for late kinds, the heavier areas unless there is danger of frost before harvest. Then they should be placed in warmer parts. For best results, clover sod land is to be preferred to that worked the previous year. In northern regions, fall plowing is popular for early varieties. There is no danger of having too much plant food. Twenty to 50 tons per acre of manure may be applied to the sod before plowing. This may be the roughest and freshest as the plants are not

injured by such material as some other crops are. Commercial fertilizers may be used with profit on sweet corn, though they often fail to pay on field corn. It is better practice, however, to apply them to other crops in the rotation and allow the corn to catch the residue. Soil preparation should be more thorough than for field corn, because the seed needs better soil conditions to germinate well, and the young plants are less sturdy. Weeds, especially of a grassy nature, must be controlled. One excellent method is to plow and harrow early, then use the weeder or the harrow weekly until planting time and the weeder once or twice after planting, even after the plants appear. If done in the warm part of the day, losses will be less than in early morning, because the young plants are then less brittle. Another method, best for second and later plantings, is to delay plowing until just before planting. Cultivation should always be shallow and often rather than deep and seldom, because the former saves moisture and does not injure the roots.

Planting. Seeds of the dwarf varieties may be planted every 8 or 10 inches in rows 15 to 18 inches apart, or in checks 18 to 24 inches apart each way. These distances are, of course, too close for horse cultivation. Larger varieties may be 10 to 12 inches between stalks in rows 24 to 42 inches apart or in hills 30 to 42 inches apart each way. In heavy soils, the seeds should not be deeper than 1 inch; in light ones, 1½ inch. Early planting should be shallower than late. For family use, plants may be started in 4- or 5-inch flower pots and transplanted after danger of frost has passed. The work necessary for 25 to 50 hills is slight, as it lasts only 3 or 4 weeks before planting. Market gardeners often get their earliest corn in this way. Another way is to soak part of the seed for a day, to keep it moist under damp burlap until the sprouts just begin to show, then to plant it at the same time as an out-door sowing of the same variety is made. If successful, it may be a week earlier than the latter.

TOMATO. A common garden vegetable of sub-tropical origin, grown as an annual. The branching vines bear fleshy red or yellow fruits which are eaten raw, as salads, or cooked, canned, pickled or used in various ways as flavoring. In South America, where it originated, it is a perennial. Being tender to frost and a long-season crop, tomatoes must not be set in the garden until danger of frost has passed, and they must then be large enough to reach maturity before the first cold snap in the fall. A rather high temperature is necessary to best development—65 to 70 at night and 80 or more during the day. Sudden drops in temperature are usually hurtful since they check growth and may injure productivity. The plants will stand considerable dry weather, but do best if the soil does not become powdery in drought.

Types and varieties. There are several types differing in shape of fruit and kind of foliage. Some have small, globular fruits forming clusters like currants, some are pear or plum-shaped, others round like an apple, and some flatter. The important commercial and garden varieties belong to these latter. Typical varieties of the different classes are: Early ripening: *Earliana, Atlantic Prize, Early Freedom;* Large fruited, *Ponderosa, Beefsteak;* Purple fruits: *Beauty, Acme, Imperial;* Red fruits: *Favorite* (late), *Honor Bright, Matchless, Stone, Trophy, Royal Red, New Jersey;* Yellow fruited: *Golden Queen, Lemon Blush;* Dwarf (or tree) type: *Dwarf Champion, Station Upright Tree, Aristocrat;* Potato-leaf type: *Livingston's Potato-leaf, Mikado, Turner's Hybrid.*

Soil. Tomatoes do best in well-drained medium loams of moderate richness. For the earliest crops, sandy loams with southern or eastern exposure are quickest; for later ones, heavier loams are best. The former usually yield a greater weight of fruit, but the latter yield fruits of firmer, less watery texture, hence better for culinary purposes. The soil is best put in shape by plowing under a heavy clover sod for a cultivated crop such as potatoes or corn the previous spring. Failing this, cowpeas, or cover crops of crimson clover or rye and vetch are excellent. Early spring plowing and harrowing followed every week or 10 days with an Acme harrow until planting time give best results after planting. Tomatoes should not be planted on poor soil, and generally do best on a soil where the crop was not grown the previous year.

Culture. Early tomatoes usually command highest prices, so most growers strive for this market. Often such fruit sells for as much a pound as late fruit commands a bushel. Plants are started under glass and managed according to one of the following plans: (1) Ten weeks before setting in the garden, sow the seed thinly in flats in a greenhouse or hotbed. When the plants have developed true leaves, transplant to 2-inch pots or other flats. Transplant again when the roots fill these pots to 3-inch pots and again to 4- or 5-inch pots. Each time the roots should have formed a mat around the earth in the pot before the transplanting is done. Should a crown cluster of flower buds appear before setting in the garden, it should be pinched off to make the plants strong and branchy and de-

Fig. 473. A desirable, stocky tomato plant ready for transplanting from the paper pot in which it was started.

velop 2 to 5 clusters of flowers instead of only 1. When planted in the garden, these clusters may be in bloom or even have some little tomatoes, so ripe fruits may be gathered perhaps 6 weeks after planting. The seedlings may be transplanted into old quart berry baskets, boxes made of stiff paper, unsoldered tin cans or similar containers, placed in flat boxes so that the plants may be removed and planted out without disturbing the roots. (2) Eight or 9 weeks before setting in the garden, sow 8 to 12 seeds to the inch in rows 2 inches apart in flats and transplant to flats 1½ to 2 inches apart each way when the first true leaves develop. In 3 or 4 weeks, transplant 4 by 4 inches in other flats or in 3- or 4-inch pots from which they are to be transplanted in the garden. (3) The same as (2) except that the time is shortened to 7 or 8 weeks. (4) Six or 8 weeks before outdoor planting, sow thinly in a hotbed in rows 3 to 6 inches apart, and either transplant to cold frames or direct to the garden after proper hardening off. The last is the poorest method of all, because the plants are likely to be leggy and to suffer from transplanting. Whatever method is followed, the young plants should be kept growing steadily but slowly so as to be sturdy and not suffer any check. Plants for late crop may be started under canvas or in open garden beds out of doors, especially from Virginia southward. They may be set in the garden when 6 or 8 inches tall. One transplanting usually gives better results than none at all. Fresh stable manure and nitrate of soda must be handled with caution, the former applied preferably the previous autumn, the latter in a moderate dose when the plants are set in the field or shortly after. Improperly applied, these materials tend to rankness of vine, and inferiority and scarcity of fruit. No mistake is likely to occur in applying either potash or phosphoric acid. Successful growers of early tomatoes favor 500 to 1,000 pounds of a fertilizer analyzing 4 or 5 per cent of nitrogen and 8 to 12 per cent each of potash and phosphoric acid. For late crops and for soils already rich in nitrogen, the percentage of nitrogen may be only 2 or 3.

Transplanting. When transplanting to the garden, the plants should suffer no check. When properly grown and hardened, they are not likely to suffer from wilting or other cause if the ground is in good condition and the season late enough. It is better to "lose" a week than to plant out a day too early and then have a cold spell or a frost. Distances between plants will depend on the variety, the method of culture and the character of the soil—as little as 3 by 3 feet in thin and poor soils with small-growing kinds, or as much as 5 by 5 feet in rich soils with large-growing late ones. Clean tillage is necessary until the plants might be injured by the machines or the hand tools.

Training. Most tomatoes are grown without any training of the vines, but for finest fruits, training is claimed to have these advantages: Earlier ripening, greater freedom from disease, larger, finer and cleaner fruits, ease of spraying, more convenient harvesting, earlier use of the land for a succeeding crop or a cover crop. Objections to training include expense, larger number of plants in a given area, placing, removing and storing of stakes, tediousness of pruning. Two general methods of training, with their modifications, are in use. One uses some sort of trellis or frame, wood or wire, to support the plants, allowing them to grow naturally. The other trains them to a single stem tied to a stake, often growing higher than a man's head. They may be set much closer when trained to stakes.

Harvesting for home use and local market should always be delayed until the fruits are fully ripe but fairly firm, as at this stage highest quality is secured; for more distant markets, the tomatoes may be gathered when they begin to turn pink or even before that, but such fruits are much inferior. When frost is expected, the fruits that show glossy skins or are further advanced toward ripeness, may be gathered and spread upon hay in cold frames, covered at night and ventilated by day. Most of them will ripen fairly well and make second-quality fruits. The vines, if pulled and hung in a frost-proof room, will ripen many of their fruits.

FIG. 474. Tomato plants pruned to single stems and trained on single pole supports.

STRAWBERRY or HUSK TOMATO. (Ground cherry). Several species of hairy annual herbs which bear yellowish, seedy, mawkish-flavored fruits, enveloped in papery husks, and which are sometimes used for preserves and pickles. Once started in a garden, they remain by seeding themselves, but they may be easily killed out by tillage.

FIG. 475. Lumbering is a splendid farm job for winter. (N. Y. Conservation Commission Bulletin 9.)

CHAPTER 29

Forest Products from the Farm

By SHIRLEY W. ALLEN, B.S.A., *Professor of Extension at the New York State College of Forestry, Syracuse University, Secretary of the New York State Forestry Association, Member of the Society of American Foresters. He was raised in Iowa where he developed an early interest in the native river bottom woods and planted groves and windbreaks. During 4 years previous to 1909, while a student in Iowa State College, he was in touch with forestry experiments of the State Experiment Station and had charge of a good deal of nursery and planting work. He spent the summer of 1908 as a laborer in the U. S. Forest Service Nursery at Monument, Colorado, and then was a member of the U. S. Forest Service in California for 5½ years. Since October, 1914, he has held his present position and has also examined a large number of plantations and woodlots on New York farms and had charge of several forest planting projects in New York State.*—EDITOR.

IN ORDER to obtain the maximum return from forest products grown on a farm, the owner must not only apply business methods to the growing and marketing of those products but also put into practice certain principles of forestry. Broadly defined, forestry is the business of raising repeated crops of timber on land not adapted to the growing of more valuable crops and of using or marketing them at a profit. The average farmer owning a woodlot or tract of idle land has, therefore, a better chance than almost any other private individual, to try his hand at making money out of forestry. Certain principles outlined in this chapter may easily be applied in the routine of farm work and bring about greater efficiency and more profit.

The woodlot, so common on all farms in eastern United States, is usually a remnant of the original native forest of the region left on the hilly or rocky parts of the farm when the original clearings were made. Ordinarily the broad-leaved trees such as birch, maple, beech, oak, and chestnut are the most numerous. In some parts of Pennsylvania and New York, good stands of hemlock and pine are not uncommon, and the white pine may be almost called the typical tree of New England farm woodlots. Most of a farm's forest products come from such an old native woodlot. Besides, it always adds to the beauty of the farm and usually is

so situated that it serves to shelter buildings and stock from cold winds. Properly managed woodlots should yield a profit ranging from 6 to 10 per cent on the investment where wood products form the only salable harvest. Where maple sugar, willow for basket making, or other special products are available, a much higher annual yield may be expected.

The planted forest. Another farm source of wood products worthy of mentioning is the forest plantation which differs from the woodlot in that it is artificial and, due to custom in planting, usually contains fewer and faster growing kinds of trees. Here and there one finds mature plantations of this sort and there is a growing tendency among farmers, especially where the planting stock is available at reasonable rates, thus to use their poor, idle land. Wornout and gullied pastures, hillsides too steep for profitable cultivation, blow lands and drifting sands and even some types of swamp land offer good opportunities for forest planting. While a man who starts to practise forestry with a woodlot already on his land has a distinct advantage in that he needs only to guide production and does not have to wait long for a crop of timber, the plantation offers him a chance to control the selection of kinds of trees, their spacing, and the placing of his artificial woodlot just where he wants it on his farm. This latter fact suggests advantages aside from the production of timber such as the use of a portion of the plantation as a grove for sheltering stock, the placing of the trees in such a position that they will act as a windbreak or shelterbelt, and the utilization of land which otherwise would be idle but not free from taxes. Where a market can be developed for the products, and where the cost of land, trees, and labor can be kept as low as $16 per acre, forest planting on poor farm land is a paying venture.

FIG. 476. Careless, ignorant lumbering methods are all too common. We must learn how to harvest our timber crops.

The windbreak. Still another source of wood products is the planted windbreak or shelterbelt. This usually consists of 3 or 4 rows of evergreen trees so placed as to shelter buildings, stock, or field crops from the effects of cold and dry winds. Trees making a quick bushy growth should be selected for this purpose, and in order to get quick results, close spacing is necessary. Later thinning out of the shelterbelt yields a large amount of farm repair material in the way of posts, rails, and cord wood, and small Christmas trees, and sometimes provides enough of these to make their sale practicable and profitable.

An almost entirely neglected source of firewood and occasionally of saw logs, is the aged and dying shade tree on the farm. This may stand out in the middle of a pasture or alongside one of the drives or farm roads. Careful watching of these trees and judicious cutting after they have passed their useful period will sometimes net a handsome bit of revenue and at the same time remove the danger of their being blown down and doing damage.

Managing the Woodlot

To bring and keep a native woodlot up to the heaviest continuous financial production, five main operations must be kept in mind, each of which involves several simple principles. These are (1) protection, (2) estimating the value, (3) thinning, (4) harvesting, and (5) marketing.

Trees Adapted to Farm Forestry in Various Regions

Northeastern U. S.	Southeastern U. S.	Middle West (East of Mississippi R.)	Prairie States
Ashes	White Oak	Ashes	Ashes
Arbor vitae	Hickory	Oaks	Cottonwood
Basswood	Georgia Pine	Elms	Elms
Beech		Hickory	Maples
Chestnut		Cottonwood	Red Oak
Elms	**South Central U. S.**	Russian Olive	Black Locust
Hickory	Oak (White, Red)	Hackberry	Honey Locust
Maples	Catalpa	Tulip	Osage Orange
Hemlock	Locust (Black, Honey)	Norway Spruce	Black Walnut
Oaks	Osage Orange	Scotch and Austrian pine	Catalpa
Pine (white, red, Scotch, and Austrian)	Cottonwood	Maples	Russian Olive
Spruces		Catalpa	**Rocky Mts. and West**
Poplar		Basswood	Norway Spruce
			Cottonwood
			Black Locust

1. Protection

From fire. Of all the forest enemies fire is the most destructive and sudden. However, it is not so common in farm woods or small isolated tracts as in wild forests where human carelessness is harder to control. The main things to do to keep fire risk down are (1) to insist on careful use of matches and tobacco when doing work in the woods; (2) make previous arrangements for controlling necessary fires in cornstalk fields, stubble patches or cleared land; (3) to maintain a few roads or trails in the woods where ground fires may be checked; and (4) promptly to dispose of dead material, slash from logging work and other inflammable stuff.

From insects. Forest trees, like other plants, are injured by insects in various ways. In general, intensive methods of control are too costly but in an area as large as the average woodlot, simple precautions will help out a bad situation. Some of these are (1) encouragement of insect-eating birds on farms (see Vol. I, Chapter 24); (2) looking after the general vigor of woods so that no weakened and easily attacked trees are long left in the stand; and (3) prevention of fire injury and unnecessary mechanical injury such as that from careless blazing of trees, chipping trees to see how they will split, and injury of healthy trees in reckless skidding or felling.

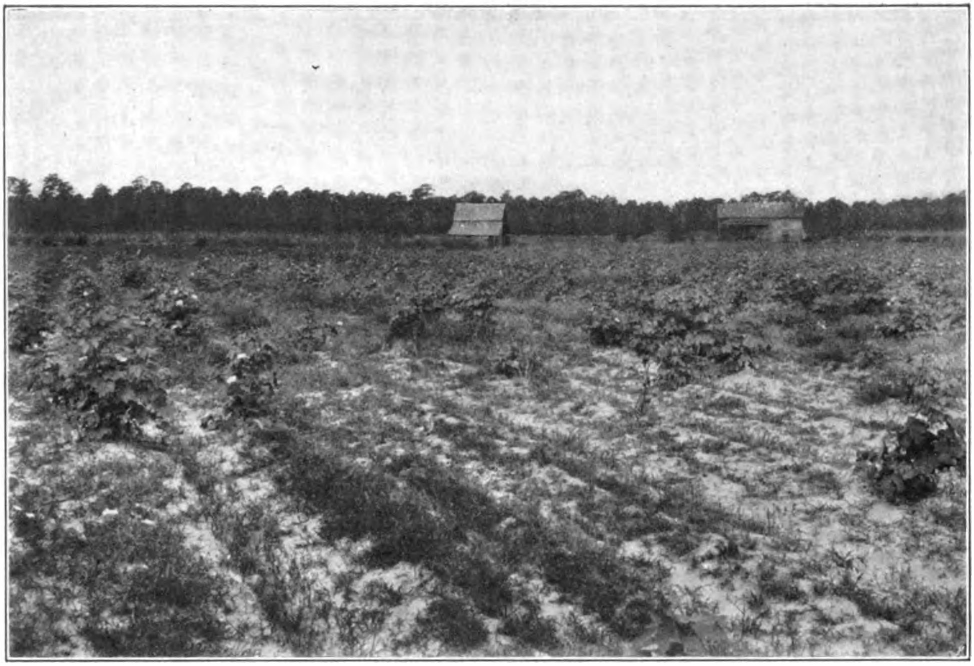
From diseases. Diseases which rob the trees of needed moisture and nourishment and weaken them mechanically, can often be retarded or entirely controlled by some of the general methods listed for insect control. The removal of weakened trees and the protection of healthy ones so that disease spores cannot get a foothold on them are important.

From stock. The grazing of farm stock injures the woodlot because the tender shoots are browsed upon and because excessive trampling compacts the soil and retards growth. The feeding value of woodlot pasturage is not enough to pay for such injury. Where the woods are expected to yield well, it will pay to fence off a small portion of the lot for a grove and to figure on getting pasturage elsewhere. The actual feed value of using the woods for pasture is not enough to pay for the injury done by stock. Hogs may sometimes be allowed in the woods for a few days just before tree seeds fall when their rooting will put the soil in good condition to receive the seed. The crowding of grass in upon the woodlot, which robs the trees of nourishment and moisture, can be guarded against by keeping the soil well shaded with young trees and filling in large openings in the forest by occasional tree planting.

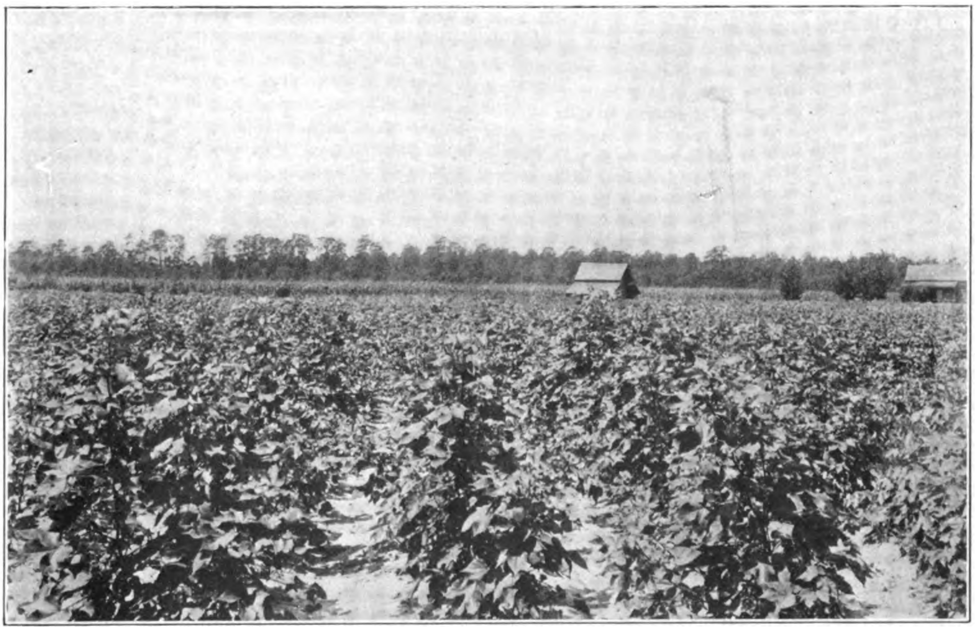
2. Finding the Value of Timber

Stock taking is an important first step in woodlot management. Lump sales of standing timber not uncommonly result in considerable losses because the owners lack knowledge, not only of the amount of timber but also of the woodlot area. A few simple methods of measuring timber are given here:

Board foot estimate, Method I. (Area known.) Count all the trees in a circle 118 feet across (¼ acre). Select a sample tree as nearly average as you can. Determine how much of the tree you can saw into 16-foot logs (8 foot logs count as halves). Add the top diameter of the top log and the bottom diameter of the bottom log (inside the bark) and divide by 2 to get the average diameter of the used length. Square this (multiply it by itself), subtract 60, multiply by .08 and you will have the contents of the average 16-foot log in that tree. Multiply by the number of logs in the tree, and then by 4 times the number of trees on your circle (since ¼ acre plot was used) and you will have roughly the contents of that acre in board feet. Example: Ash 85 feet tall will saw out 40 feet or 2½ logs; top and bottom diameters inside bark (estimated) 10 and 20 inches; $10 + 20 = 30$;

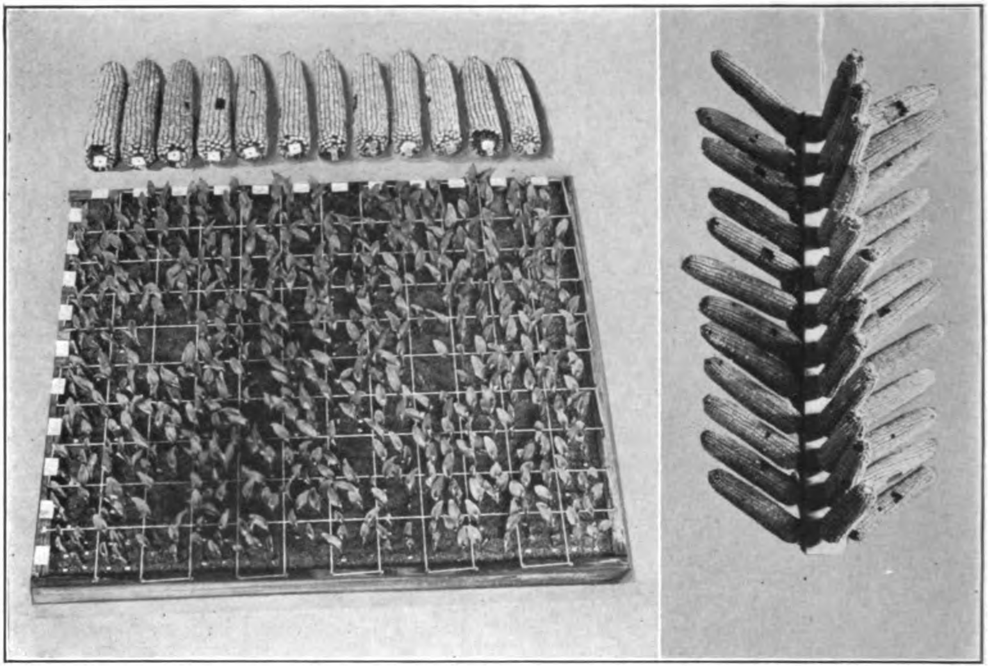


Plants as well as animals can be bred healthy. · This is a field of upland cotton destroyed by wilt
(These photographs from the U. S. Bureau of Plant Industry)



This field, handled otherwise like that above, was planted to an improved, wilt-resistant strain developed by the U. S. Department of Agriculture

THE SCIENCE OF BREEDING IS DOING WONDERS IN BOTH THE IMPROVING AND THE PROTECTING OF FARM CROPS



By testing his seed, and carefully selecting and caring for it, the farmer, as well as the scientific breeder, can help to raise the quality and yields of the Nation's crops

But even the best of crops must be protected. *At left* a watermelon vine killed by anthracnose; *at right* a nearby vine kept healthy by spraying. (U. S. Bureau of Plant Industry.)

SCIENTIFIC MEN CAN POINT THE WAY, BUT IT IS "UP TO" THE FARMER TO DO THE REAL WORK IN CROP IMPROVEMENT AND PROTECTION

$30 \div 2 = 15$; $(15)^2 = 225$; $(225 - 60) \times .08 = 132$ (board feet); $132 \times 2\frac{1}{2}$ (logs) $= 330$ (B. F. or contents of tree); 330×10 (number of trees on plot) $\times 4 = 13{,}200$ B. F. per acre. Work out 8 or 10 such sample plots to get the average stand per acre and multiply this by the number of acres in the tract.

Board foot estimate, Method II. (Area unknown.) If the woodlot is roughly rectangular in shape determine the length in rods by pacing or better, by measuring, and divide this into strips an equal number of rods wide (20 is convenient if it will work). Next, by the aid of a pocket compass walk lengthwise through each strip, counting all trees for a rod on each side of your path, selecting your average tree, and recording its dimensions as in the first method. At the end of the strip figure out the board feet in the average tree and multiply by the number of trees you have counted on the strip 2 rods wide. If the divisions are 20 rods wide, the area of the 2-rod strip is 1/10 of that of a division and 10 times the board feet on the strip will be the contents of the division. Do this for each division and add the results to get the contents of the entire woodlot without knowing the area. If the woodlot was 762 rods long then it would divide evenly into divisions 22 rather than 20 rods wide; in this case a 2-rod strip would be 1/11 of a division instead of 1/10.

Cord wood estimate, Method I. To estimate cord wood on a woodlot the above methods may be used if the board feet are changed to cubic feet allowing 8 board feet to 1 cubic foot and adding $\frac{1}{4}$ for limbs. A cord of wood (4 feet wide, 4 high, and 8 long) contains 128 cubic feet of stacked wood, but, depending

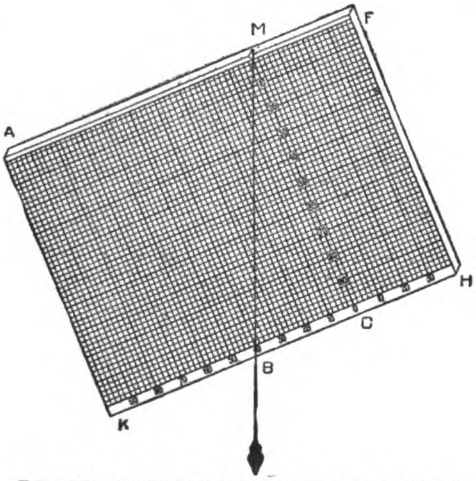


FIG. 477. Homemade height measurer made of a board about a foot square with ruled paper pasted on it. The edge AF must be parallel with the lines on the paper. The line MC is numbered from 0 to 100; and the line KH in both directions from C, using the same unit. A weighted thread is attached at M (the zero point) so that it hangs free.

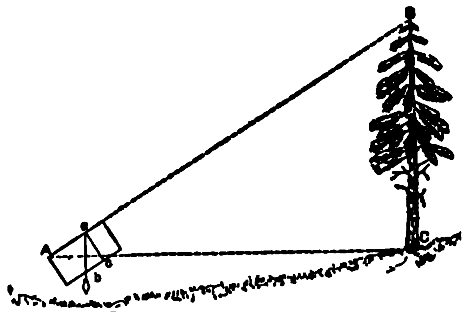


FIG. 478. In getting a tree's height stand a measured distance from it AC, and sight along the side of the board to the top. Where the thread crosses the line corresponding to the distance you are from the tree, there is the height. For instance in Fig. 477, if you were 100 feet from the tree, take the line KH which is 100 units from M; the tree is then 40 feet high. If you had stood 50 feet from the tree, the thread would show the height to be 20 feet; and so on.

on the shape and smoothness of the sticks, and the way they are piled, it may contain from 85 to 100 feet of solid wood. A safe average is probably 90. Thus if an acre of woodlot is found to contain 15,000 board feet of lumber it will have, of cordwood, $15{,}000 \div 8 = 1875$

$$+ \left(\frac{1875}{4} = 469\right) = 2344 \div 90 = 26 \text{ cords.}$$

A tree grown in the open will, of course, yield more cordwood than one of equal diameter and height grown in the forest because of the larger and more numerous limbs.

Cord wood estimate, Method II. In estimating cordwood on sprout land where the timber is too small for a board foot estimate, woodchoppers sometimes count the number of 4-foot sticks in an average cord (1); then find the number of 4-foot lengths in the average sprout (2); multiply this by the number of sprouts on a sample plot usually 2 rods square (3); divide (2) by (1) to get the number of cords on the plot; and multiply by 40

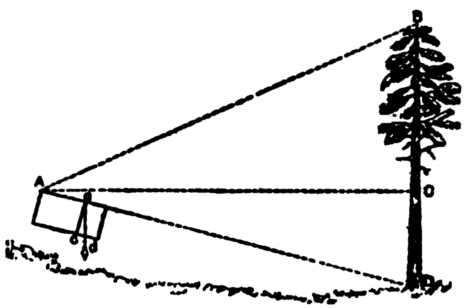


FIG. 479. If you are above the tree get first the height BC, then the distance CD by tipping the board the other way and reading along the line CH. If on a level with the tree, add to its estimated height, the distance from your eye to the ground. (This and Figs 477 and 478 from Conn. Bulletin 62.)

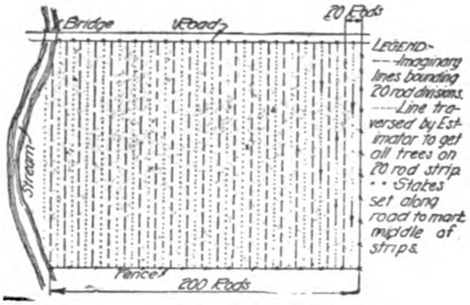


FIG. 480. Showing arrangement and route taken in estimating the amount of lumber in a woodlot

to get the cordwood contents per acre. Along with the stock taking notes can be secured on amount of crooked, dead and weed trees or slow growers (valueless for most purposes) such as dogwood, hawthorne, ironwood, blue beech, and juneberry or "service berry." Such trees may be spotted for cutting by chalk marks or a daub of whitewash, and the notes may be used to figure out markets for the material resulting from step next discussed.

3. Thinning to Improve the Stand

This involves removal of the unprofitable trees or those which occupy the ground at a loss to the owner. These should be worked up into cord wood, posts, poles, and other farm repair material; in some cases they will yield saw logs. The material can be stacked for seasoning if an immediate market is not available, but constant effort should be made to develop a local market (p. 402). Such improvement cuttings may be made any time of year and offer profitable employment for men and teams on rainy days and slack times during haying and harvest as well as in winter. Products are removed more easily and probably with less damage to remaining live timber, done in winter, which is, of course, the dormant period in tree life. In an average eastern woodlot the first improvement cutting would probably take the following classes of trees: Weed trees (mentioned above) which would be good only for cord wood or small rails; a few stunted white and red oaks shaded out by hickory or other oaks; a few maples weakened by borers and badly crowded; a number of wind-thrown trees of different kinds, a hollow-butted beech; and several birches and other trees with shelf fungi growing on them. In New England white pine country, gray birches and pines of poor form would be the trees to cut, and in the river bottom woods of the Middle West aged, dying elms and maples and other hardwoods stunted by shading and stock trampling would need to come out.

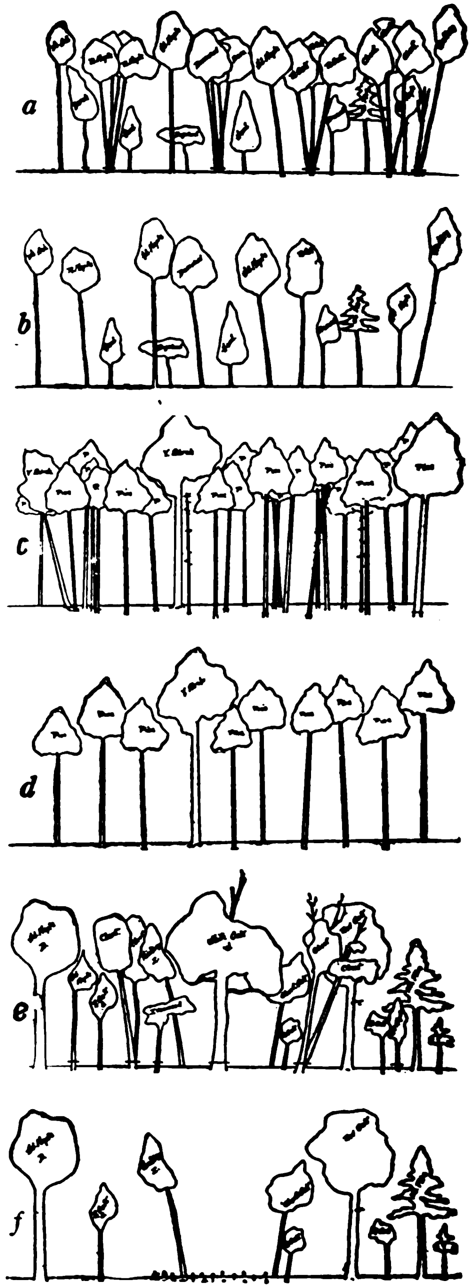


FIG. 481. Examples of good thinning. *a* Crowded white pine grove before and (*b*) after thinning; *c* mixed hardwood sprout stand, too crowded, too many stumps, before and (*d*) after thinning; *e* culled hardwoods before and (*f*) after thinning; the space left by the removal of the large white oak has been replanted with seedlings. (N. Y. Conservation Commission Bulletin 9.)

4. Harvesting Woodlot Products

The nature of farm work will not always allow the harvesting of various woodlot products at a certain planned time, but fortunately market demands allow irregular harvesting with a good chance of maximum financial returns. Winter is the most convenient time for logging in general. Tools needed and organization of the work are matters of local practice and common knowledge. Care in protecting young growth, the leaving of an ample number of vigorous seed trees and the burning of slash in winter will be worth while in any woodlot. A thin-bladed 3½-pound double-bitted ax is good for general chopping and an ordinary cross-cut saw for falling and bucking. Soft wood of evergreen logs such as pine, spruce, and hemlock are usually sawed in lengths of 10, 12, 14, and 16 feet, while logs from broad-leaved trees, such as elm, maple, and oak run shorter and in both odd and even lengths. In fairly level country 2 to 3 tons, or from 3 to 5 average hardwood logs, is the maximum sleigh-load for a heavy 2-horse team. A wagon-load must be one-third lighter. At ordinary farm wages, the cost of woodlot logging per thousand board feet is usually about as follows:

Felling	$1.00
Skidding	3.00
Loading	.75
Hauling (1 trip a day)	4.50
Total	$9.25

Sprout land in the Northeast where chestnut, soft maple, oak, and other hardwoods are common may be cut clean; stumps should be left sloped so they will drain, and not with a "V" shaped cut which will retain water and cause rot. Most sprouts should be cut at less than 40 years old if the vigor of the stump is depended upon for later sprout crops, and it is well to have a few old seed trees so that seedlings may be coming on to replace worn-out sprouting stumps. The ax alone is best for felling small timber such as sprouts for cord wood, ties, posts, and poles. Sometimes the common bucksaw with the pole sawbuck is useful in working up cord-wood. (Fig. 483.) In some localities fire-wood is sold in 4-foot lengths and "bucked" into stove lengths by gasoline engine buzz saw outfits whose owners make this their principal business. When absolute lack of market for logs makes it necessary to use large trunks for cord wood, these may be bucked into short lengths in the woods and split into wide, flat pieces. The work of stacking is then easier and in many localities the wood sells as stove length for the same price as if split into smaller sticks. Seasoned cordwood is worth more money than green, because less of its heat is needed to drive off the water in the form of steam; a good supply for home use and sale may be kept ahead by using occasional slack times for cutting standing dead trees, which should, of course, be out of the way in the woodlot. Chemical wood (used for destructive distillation) is usually bought by chemical companies in 52-inch lengths. The cost of cutting and stacking cord wood averages about $1 per cord for small stuff and $1.25 for large trees which must be split; hauling in average rolling country (one trip a day) costs from $2.50 with sleighs, to $3.25 with wagons. Railroad ties are bought according to specifications furnished by engineering departments of all railways, which should be carefully studied before ties are hewn for market. Ties are usually cut, hewn, and loaded on cars for slightly less than $.50 per tie. Fence posts of durable kinds such as chestnut, white oak, and white cedar should be cut 7 feet long and piled loosely for seasoning before being put on the market. Posts are ordinarily cut and piled for seasoning at a cost of 5 to 8 cents apiece. Less durable woods such as soft maple, cottonwood, quaking aspen, basswood, black ash and birch are marketable if the butts are charred or treated with a preservative. Charring is somewhat bothersome but can be accomplished quickly and on a large scale by brushing the butts with tar or crude oil and then firing them. The coat of carbon thus produced resists decay and makes the posts last from 4 to 8 years longer than they would otherwise. The best preservative for posts and other farm repair materials is a heavy oil called creosote. Posts of the less durable kinds may be made useful by a brush coat of hot creosote if care is taken to see that

FIG. 482. Firelanes are of little use unless kept clean and open.

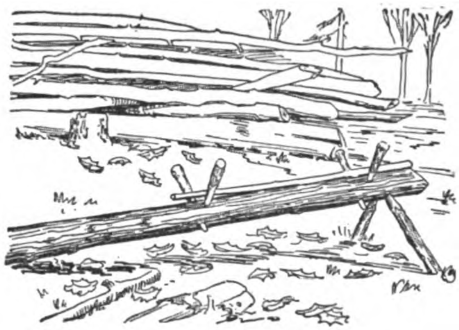


FIG. 483. Pole sawbuck for working up timber in the woods

they are dry and well seasoned. Penetration of ½ inch or more of the wood with the creosote may be secured by dipping the posts in a drum of the hot oil and allowing them to remain there until cold or from 2 to 4 hours. The brush coat will add a few years to the life of the posts which would otherwise rot off at 3 years; posts treated in the creosote bath should be good for 20 years or more. Several farmers in a locality may combine and use a treating plant together to advantage. Where more than 500 posts are treated at one time, the cost is about 12 cents per post.

5. Marketing Woodlot Products

In working up a market for cord wood, local bakeries, brick yards, wood distillation plants, military camps and other industries that use it should be canvassed for orders and contracts secured, so that payment will not be held up later on. A brisk domestic demand may be built up by house-to-house soliciting in cities and villages where fireplaces are common and in some instances people are willing to take dead wood at a slightly reduced price and to await delivery until it can be brought in on a sleigh. Judicious use of want advertisements in village and city papers will often bring orders for a winter's work and the advertising of a specialty such as "fireplace chunks" will establish a reputation for quality. Small loads may be brought in with other produce

FIG. 484. This wood lot is too open; a thicker stand gives better timber

to public markets with assurance that sale for them will be found; in short, the attention to marketing which the importance of the woodlot crop deserves will net good returns. Besides the portable mill and small local sawmill markets for logs, there is an increasing demand for logs of birch, elm, maple, and beech for basket veneers, for hickory and ash for handles and implement parts, and, near furniture or other manufacturing centres, for logs of all kinds to be made up into crating. In many states wood-using industries have been studied and reports giving the addresses of firms needing special kinds of woodlot products have been published. These and other marketing helps can be secured from the state forestry schools or departments.

Starting and Caring for a Plantation

The waste areas and patches of poor land on a farm are good places on which to start a woodlot if there is none, or with which to supplement the small or insufficient farm woods. Planted timber is more necessary in the treeless prairie country and good results have been obtained with some of the quick growing kinds listed in the table; older plantations, especially where evergreens were used, show good returns in the East. Gullied pastures, wornout fields and sometimes even good, fertile land may be selected for planting in the Middle West and the same types plus steep but fertile hillsides in the eastern states. Direct planting with tree seed is usually unsuccessful because field mice and squirrels steal the seed. However, nursery stock can be purchased for from $2 to $6 per 1,000 trees. according to age and whether or not they have been transplanted in the nursery. For broad-leaved trees such as ash, red oak, cottonwood and catalpa, 1- or 2-year-old seedlings are best, while in the case of white or red pine and Norway spruce, 4-year-old transplanted stock gives best results. Trees can be obtained at cost

FIG. 485. Wood to be used in the manufacture of chemicals stacked in a factory yard

FIG. 486. The three operations in planting a seedling: *a* removing a piece of sod with mattock; *b* setting the tree as soon as taken from the pail of water; *c* treading the soil firmly around it.

from many of the state forestry departments and state forest schools and seedling stock for "lining out" may be purchased reasonably from nurserymen and grown and transplanted in the home garden for a year or two before being planted in the open. Planting costs must be kept as low as possible and only small inexpensive trees used if the venture is to be financially successful.

The work of planting the trees is simple. One man goes ahead with a mattock or grub hoe digging a line of holes 4 or 6 feet apart; behind him follows a man with a supply of trees in a pail or a wet sack (so as always to keep the roots wet) who sets out the trees much as one would put out a tomato plant, except that no water is used. The soil must be firmed about the roots with the hands or by tramping. If there is sod on the land, a square foot of it or more should be removed where the hole is to be made for the tree. If spaced 6 x 6 feet apart, 1,210 trees per acre are needed; if spaced 4 x 4 feet, 2,724. Two good men can plant from 800 to 1,500 trees in a day, depending on the character of the land. The filling in of open places in a woodlot by planting is slower work, but the general plan is the same.

The 6 x 6 foot spacing is usually best for evergreens and mixed plantations. Where land is level enough to be plowed, furrows every 6 feet may be used in planting oaks, ashes, poplar cuttings and other broad-leaved trees. Very cheap and effective planting of Carolina poplar cuttings has been accomplished by placing cuttings in such furrows and throwing the dirt against them with the plow.

Thinnings should begin in a plantation when the trees start to interfere with each other, and when the material obtained will pay expenses. Care should be taken not to thin out too much at a time since competition forces the desired rapid upward growth, and shade prevents grass from starting. No profit should be expected from this first thinning which usually becomes necessary 10 or 12 years after an evergreen plantation is started and 6 or 7 in the case of the fastest growing hardwoods. When height growth is about complete, that is at 25 or 30 years, more crown or leaf surface should be allowed to develop to insure rapid diameter growth on the trunk. Some of the by-products of thinning a plantation are bean and hop poles, cord wood, small posts, garden stakes and vineyard props.

Starting and Caring for a Windbreak

A belt of trees consisting of 2 or more rows at right angles to the direction of the prevailing cold and drying winds, will increase the yield of crops in the protected fields over an area 10 times as wide as the height of the break, up to 20 per cent. Quick results from a windbreak are usually imperative and a row of rapidly growing trees such as the Lombardy or the Carolina poplar may be planted temporarily. These should be placed about 6 feet back of the Norway spruces, white, red, or Austrian pines or other trees which are to form the permanent windbreak. When the evergreens have

FIG. 487. A 20-year-old Norway spruce windbreak

FIG. 488. A 30-year-old eastern windbreak that has grown at the rate of 3 cords per acre per year.

reached a height of 25 to 30 feet, the poplars will be large enough to cut and use for logs, cord wood, and farm repair material. Because a smaller number of trees are needed in starting to establish windbreaks as compared with a plantation, they should be older, and greater care should be taken in planting. Five- or 6-year-old transplanted evergreens, and 3-year-old seedlings of such trees as soft maple, Russian olive, or green and white ash and 3-year-old rooted cuttings of the poplars and white willow are best. A double row windbreak using such trees can be started at a cost of from $3 to $5 per rod.

In an interesting instance of windbreak management a New York farmer, to protect his orchard, planted alternately in the same rows, Norway spruces and Carolina poplars, spacing them 6 x 6 feet but staggering the rows, that is, putting the trees in one row between instead of opposite those in the other. (Fig. 489.) The poplars grew much the faster, but when the spruces were sufficiently developed, they had so great a spread of branches that the poplars were no longer needed. By this time, too, the poplar roots were causing trouble with nearby drainage pipes so these trees were taken out carefully to prevent injury to the spruce. There resulted some posts which were valuable when treated with creosote, a few sawlogs and a quantity of cordwood and, in addition, the farmer now has his windbreak fully developed. Even where shelterbelts are of only one kind of tree, it often becomes necessary, 10 or 15 years after planting, to take out some trees to insure the best permanent development of the rest.

In many sections of heavy snowfall, country roads can be kept open almost permanently by the planting of windbreaks along them or inside the fences on adjoining farms. The fact that trees along the outside of a stand can develop branches throughout their entire height, enables a windbreak of 2 or at most 3 rows of trees to show faster growth than a solid plantation. A windbreak in the Middle West, made up of common cottonwood, yielded at the age of 14 years, $15 per acre per year over the cost of production plus savings bank interest on the original investment which was about $17 per acre. The material harvested was posts and cordwood. An eastern windbreak of Norway spruce produced an average of 3 cords per acre per year for 30 years in spite of severe ground fire injury and a very poor, sandy soil.

Basket Willow Culture

This may be carried on in connection with farming where there is land which, for a portion of the year, is overflowed so that it cannot be used for a regular grain crop. For successful growth the willow demands fertile, loamy soil, an abundant supply of moisture and fair drainage; land which is always wet will not produce well. A plantation or "holt," is started with cuttings which may be secured from willow growers in the spring at $3 to $4 per thousand, but which should be ordered the previous fall. Land should be thoroughly plowed and the cuttings set 1 to 1½ feet apart in rows 3 feet apart, before growth

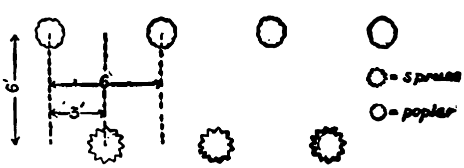


FIG. 489. How to "stagger" trees in a windbreak of quick-growing (poplar) and slow-growing (spruce) trees.

starts. If the ground is mellow enough the cuttings can be stuck in, but it is safer to make a hole with a small iron rod which prevents injury to the bark and later loss by rotting. Only the 2 or 3 top buds should be left above the ground. Early frequent cultivation for the first 2 years is necessary to keep down weeds. Mulching with straw or leaves largely prevents alternate freezing and thawing and, as a result, heaving. Barnyard manure, wood ashes and lime, should be supplied if willows are grown for a number of years and these may be used in mulching. The crop is usually harvested annually, but it is well to allow the rods to grow for 2 years without cutting every 6 or 8 years to renew the vigor of the stumps; the rods resulting from 2 years' growth will be coarse but marketable.

The first year's crop will be too poor to market but will supply cuttings for extending and filling in the holt. These should be taken between the beginning of winter and the starting of spring growth; the cuttings for planting should come from the lower two thirds of the rod. They should be about 10 inches long and may be stored in moist sand in a cool place or piled in bundles against a shed and covered with cornstalks or straw until planted. The second year will yield about half a crop of 4 tons of rods to the acre. These are cut with a knife or special sickle early in winter and put into bundles convenient for handling. They are usually sold without peeling and bring from $15 to $25 per ton at the holt. The following table from Circular 18, N. Y. State College of Forestry, gives average costs and returns per acre:

Expenses	First Year	Second Year	Third Year
Preparation of soil	$10.00	.....	.....
Sets, 35,000 9″ x 20″ at $1.50	52.50	.....	.....
Planting	10.00	.....	.....
Cultivation and replacing	15.00	$15.00	$15.00
Spraying if necessary	.....	5.00	5.00
Cutting rods at $6.00 per ton	8.00	24.00	42.00
Total cost	$95.50	$44.00	$62.00

Returns at $25 per ton

First Year	Second Year	Third Year
1½ tons—$37.50	4 tons—$100	7 tons—$175
Loss—$58	Profit—$56	Profit—$113

Total profit 15 years	**$1,467.00**
Average annual profit 15 years	**97.80**

Fig. 490. Cutting basket willow rods

The varieties of willow principally used for growing rods are *American*, *Lemly*, *Caspian*, and *Purple*. The centre of the basket willow industry in this country is Liverpool, New York, a small village near Syracuse.

By-Products of the Woodlot

Sugar and sirup. Throughout the commercial range of the sugar maple, the maple sugar industry is important either as a sideline to lumber production or as the special purpose of the sugar bush. Unlike the woodlot in which the object is height and size with the least leaf surface, the best sugar bush contains fewer trees but each with a larger crown (more leaf surface). Natural woods conditions must be maintained, however, and grass should not be allowed to crowd out young trees. When a sugar bush is 40 to 50 years old, there should be about 100 large trees to the acre with young ones coming on; in some cases it pays to plant young maples in the more open spaces. The average sap season is from the last week in February through March; weather with alternate freezes and thaws gives the best flow. Average trees yield 10 to 12 gallons of sap a year containing from 4 to 6 per cent of sugar, although some sap carries 10 per cent.

In tapping a tree it is best to use a ⅜-inch bit and make the hole about an inch deep into the wood. Either patent metal spouts or wooden ones made from elder sticks may be used. It will pay to use covered buckets since bits of bark or other waste in the sap are likely to cause it to sour. The sap is usually boiled down into sugar and sirup in the woods or in nearby sheds. Impurities are skimmed off as they reach the top and when the boiling sap reaches a weight of 11 pounds to the gallon it is ready to put up in cans as sirup. "Sugaring off" is the term used to indicate the condition of the boiling sirup when ready to be cooled for sugar, which is determined by test-

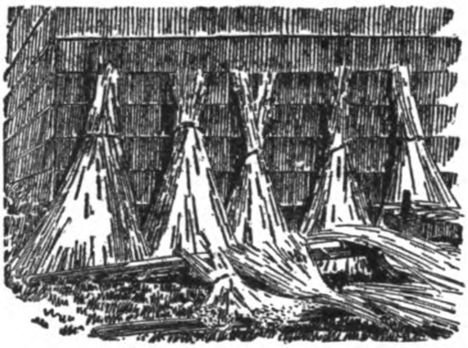


FIG. 491. Basket willow peeled and stacked for drying

ing it out in snow or cold water. A waxy texture shows that the right stage has been reached.

Tan bark. Oaks, chestnut, and hemlock yield bark which is used in tanning leather. Late spring or even early June at the time of or directly after felling the trees, is the time to peel oaks and chestnut. In some regions the first 2 lengths of bark are taken off while the tree is still standing, a "spud" or long iron rod with a chisel-like end being used to loosen it. Hemlock will peel readily throughout most of the summer. About a week is required to dry the bark after which it is corded up to await hauling to market. Prices range from $8 to $15 per cord.

Wintergreen oil. The black or cherry birch, common in northeastern United States yields an oil which strongly resembles that obtained from wintergreen, for which it is used as a substitute. Branches and twigs which would otherwise be wasted are sometimes sold to distillers for this purpose.

Tree seed. With the increased interest in and need for tree planting throughout the country, the collection of tree seed may be made the source of considerable revenue. Nuts may be gathered in the fall and sold either to local grocers or fruit men, and evergreen seeds may sometimes be gathered when logging is in progress. The cones of the pines and spruces are gathered and spread out on trays in a warm room to dry. The seed can then be trampled or flailed out and put through a fanning mill till clean. Nurserymen pay good prices for evergreen seed of good quality.

Turpentine orcharding. This industry is practised in the southern states, the largest yield of "dip" or pitch coming from the Georgia or long leaf pine. In some sections woods in old fields are leased out for turpentining privileges and occasionally farmers gather and market the dip themselves. The bark is taken off over a spot 8 or 10 inches wide and as high as a man can reach; a V-shaped gutter is fitted at the bottom of this "face" and a patent cup secured to the trunk just below; the tree is then scored with a large curved knife or "scribe" diagonally down from both sides of the face to the middle to increase the flow of pitch. Several faces can be placed on each trunk if the tree is large enough but the practice of tapping young trees retards growth without giving a permanently increased yield.

FIG. 492. The maples along an entrance drive can serve as a source of profit as well as objects of beauty. Careful tapping does not harm them

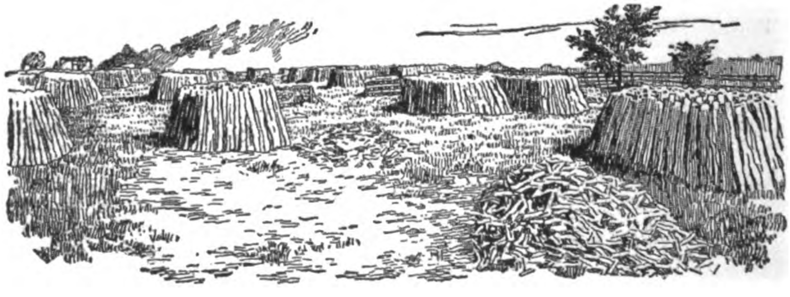


FIG. 493. A good crop of catalpa posts. (Kans. Circular 20.)

Requirements and Uses of Good Trees for Farm Forestry

TREE	CONDITIONS REQUIRED	RATE OF GROWTH	USES OF TREE	KIND AND USES OF WOOD
Ash (green, white)	Fairly moist fertile soil	Medium	Plantation	Heavy, tough—handles, vehicle stock
Arbor vitae	Moist swampy soil	Slow	Swamp plantation and windbreak	Light, brittle—posts, poles
Basswood	Fertile, fairly moist	Fast	Woodlot, plantation, ornamental	Light, tough, even grained—lumber, trunks, excelsior
Beech	Fairly fertile moist	Slow	Woodlot and ornamental	Heavy, hard, tough, interior finish, furniture
Catalpa	Very fertile, fairly moist	Fast	Plantation, ornamental	Light, coarse-grained, durable—posts and poles
Cottonwood or poplar	Fairly fertile, moist	Fast	Plantation and windbreak	Light, tough—lumber, boxes, and crating
Chestnut	Medium, fertile and not too moist	Medium	Woodlot (sprout forest) outside blight region	Light, coarse-grained—Ties, posts, poles, and lumber
Elm (white, red)	Fertile and moist	Slow	Woodlot and ornamental	Heavy, hard, tough—basket veneers, hubs, implements
Hackberry	Poor dry soil	Slow	Plantation, mixed with burr oak	Cordwood, veneers, and posts (treated)
Hickory (shagbark)	Fertile and moist	Slow	Woodlot (sprout)	Heavy, hard, tough—vehicles, handles, implements
Hemlock	Fairly fertile and moist	Slow	Woodlot	Light, quite strong—lumber
Locust (honey,	Poor dry	Fast	Plantation	Heavy, hard, durable—
black)	Poor dry	Fast	Plantation	posts, insulator pins
Maple (hard)	Fairly moist and fertile	Slow	Sugar bush, plantation and ornamental	Heavy, hard, tough, used for furniture, instruments, and flooring
Maple (soft or silver)	Fertile and moist	Fast	Windbreak, woodlot (sprout)	Light, soft—cordwood and lumber
Osage orange	Fertile, dry	Medium	Windbreak	Very hard and durable, posts and dye wood
Oak (white)	Rich, moderately moist	Slow	Woodlot	Heavy, hard, strong—ships, furniture, cooperage, lumber, ties
Oak (red)	Same	Medium	Plantation and ornamental	Similar to white oak but not so strong lumber—furniture and ties
Pine (white)	Poor, sandy, rather moist	Fast	Woodlot, plantation, windbreak	Soft, easily worked—lumber, pattern-making, boxes
Pine (red)	Same	Fast	Same	Hard, somewhat pitchy lumber
Pine (Scotch)	Same	Fast	Plantation and windbreak	Soft and light—lumber, box boards, crating
Pine (Austrian)	Same	Medium	Same	Same
Pine (Georgia) (or long leaf)	Fairly fertile, moist sandy	Fast	Plantation and woodlot in South	Hard, pitchy, strong—lumber, especially timbers
Spruce (white)	Poor, moderately moist	Medium	Windbreak, ornamental and plantation	Light, soft—pulp, box boards, lumber, sounding boards
Spruce (Norway)	Same	Fast	Same	Same
Tulip or Yellow poplar	Rich, deep fertile and moist	Medium	Woodlot and ornamental	Light, soft, easily worked—lumber, boxes, pattern making
Walnut (black)	Same	Slow	Same	Hard, dark, easily polished—furniture, green stocks, cabinet work

FIG. 494. Trees well placed about a farmstead, protect it, beautify it, increase its value and invest it with the air of comfort and hospitality that marks a real home

CHAPTER 30

How to Grow and Use Ornamental Plants

By PROFESSOR M. G. KAINS *(see Chapter 21). Edited by* LEONARD BARRON, *Editor of "The Garden Magazine," and an experienced, practical authority on all phases of gardening. On too many farms the ornamental garden is an undeveloped resource, either because the farmer does not know how to make and care for it; or because he thinks of it as a useless, expensive luxury and refuses to give it deserved space or attention. This is unfortunate, for flowers, shrubs, and trees well chosen and well placed, require surprisingly little outlay of time or money, and add tremendously to the beauty and comfort of a farmstead—and to its cash value as well. They make the difference between a house and a home (see Vol. IV. Chapter 10). This chapter tells what plant materials meet the needs of the farmer and his family, and how to make best use of them.*—EDITOR.

IN THE flower garden may be included those plants, large and small, that are grown for ornament or pleasure. The aim with each gardener should be to make his garden express his own likes regardless of Mrs. Grundy or any other neighbor. Gardens so planned and managed are sure to be a joy to their owners because they manifest the character of the person rather than echo the ideas of other people. Often they may be made and maintained at less cost than the so-called fashionable gardens. Anyway the plants which the gardener himself loves are likely to produce more happiness than those purchased simply because they are "in style."

No matter how poor the land some kinds of plants will thrive in it. There is just one way to prevent everything that is not wanted from growing on a given piece of land: stir the soil every little while. If you let it alone for a week during the growing season, it will begin to turn green with little plants—mustard, morning glory, thistles, burdocks, melilot—weeds, of course, but where they'll grow something else will also. Even the dump heaps of ashes, plaster and other waste, if let alone, will be buried in verdure in 2 or 3 years. Here is the hint for the gardener: Choose those species of plants that are likely to thrive in the soil you have and without a lot of preparation and coddling, and you will have far

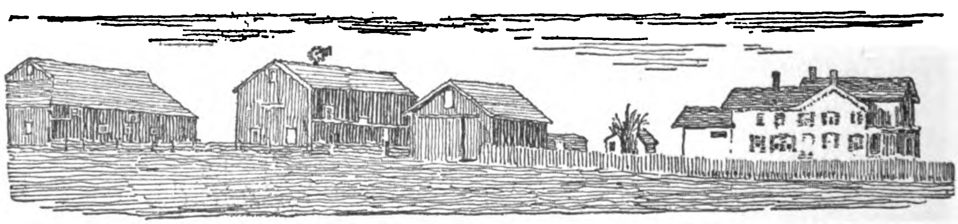


FIG. 495. In style, location, and arrangement this farmstead resembles that in Fig. 494 above, but is there any question in your mind as to which you would choose to live in? Trees make the difference

more pleasure out of your garden than if you try to compel other plants to grow where they don't find congenial conditions.

For these reasons the hardy bulbs and the hardy perennials are recommended, because, when once planted, they need little or no attention for several to many years, yet every season they gladden the eye and the mind with their beauties of form and color. The next general choice would be among the flowering shrubs which in many cases are fully as satisfactory. If space permits, flowering and ornamental trees may next be included; some hardy vines and annuals, and some of the tender bulbs and bedding plants may be added to suit individual preferences. The shady areas may be planted with favorite shade-loving wild plants from the woods and the banks of ponds and brooks; the damp places with water-loving subjects. The "flowers of the garden"—that is those plants, not of a woody nature, that are grown for their blooms—are grouped for cultural purposes into three divisions: (1) *Annuals* that are grown and flower from seed within the year and then die. In common practice plants of longer duration in mild climates that succumb to frost and which will flower the first season are included in this group. (2) *Perennials,* those plants that live on from year to year and reappear each season. (3) *Biennials,* an intermediate group that make a rosette of leaves the first year, then flower and die the second season. Divisions (2) and (3) are not absolute as some few plants behave either way or both ways, according to latitude and altitude. There is no dearth of material; the whole thing lies in the choice. The following lists are merely suggestive:

Annuals. *With fragrant flowers:* Sweet alyssum, Bartonia, Mignonette, Sweet pea, Ten weeks stock. *For sunny places:* Amaranth, Balsam, Hyacinth bean, Rose moss, Nasturtium, Gaillardia. *For shady places:* Godetia, Musk-plant, Nemophila, Pansy, Tarweed, Torenia. *For rocky places:* Baby's breath, Candytuft, Catchfly, Clarkia, Nasturtium, Rose moss. *For sandy soil:* Clarkia, Coboea, Godetia, Nasturtium, Portulacca, Zinnia. *For heavy soil:* Sweet alyssum, Chrysanthemum, Godetia, Sweet pea, Petunia, Zinnia. *For cold climates:* Sweet alyssum, Clarkia, Marigold, Pansy, Sweet pea, Ten weeks stock. *For warm climates:* Amaranths, Balsam, Moonflower, Morning glory, Nasturtium, Rose moss. *Drought-resisting:* Hyacinth bean, Ice plant, Nasturtium, Petunia, Rose moss, Zinnia. *Blooming after frost:* Sweet alyssum, Candytuft. Clarkia, Marigold. Phlox drummondi, Ten weeks stock.

Annuals often started in hotbeds for extra early flowers out of doors are Aster, Balsam, Cockscomb, Dahlia, Canna, Carnation, Cosmos, Heliotrope, Marigold, Larkspur, Moonflower, Pansy, Phlox, Salvia, Verbena, Geranium, Stock Dianthus. *Flowering plants often grown in cold frames* over winter include English daisy, Canterbury bell, Cowslip, Forget-me-not, Violet and Pansy.

Perennials. *For cut flowers:* Anemone japonica, Columbine, Giant daisy, Gaillardia, Gas-plant, Larkspur, Pink, Sweet rocket, Snapdragon, Sunflower. *Fragrant flowers:* Gas-plant, Golden tuft, Ground nut, Rock-cress, Sweet rocket, Scotch pink. *Everlasting flowers:* Ammobium, Briza, Bromius, Cat's ear, Helichrysum, Statice. *Climbers:* Butterfly pea, Clematis, Dolichos, Ground nut, Hop, Perennial pea. *Blooming 2 months or longer:* Coral bells, Golden Marguerite, Perennial pea, Iceland poppy, Sunflower (Helianthus) Multiflorus, Poppy-mallow. *For sunny places:* Cone-flower, Gaillardia, Golden Marguerite, Poppy-mallow, Rock-cress, Sunflower. *For shady places:* Anemone, Bluebells, Bugle-weed, Hellebore, Phlox, Shooting star. *For cold climates:* Goldentuft, Lychnis, Moss pink, Iceland poppy, Sweet rocket, Saxifrage. *For warm climates:* Chrysanthemum, Cone-flower, Dianthus, Funkia, Gunnera, Iris. *Drought-resisting:* Baby's breath, Cone-flower, Inula, Sedum, Sunflower, Yucca. *Blooming after frost:* Chrysanthemum, Golden tuft, Gaillardia, Golden rod, Perennial pea, Iceland poppy. *For rocky places:* Anemone, Bluebells, Columbine, Moss pink, Rock cress, Sun rose. *For sandy soil*: Blazing star, Helichrysum, Poppy-mallow, Sacaline, Sunflower, Sun rose. *For heavy soil:* Columbine, Forget-me-not, Gas plant, Larkspur, Peony, Phlox. *For low moist ground:* Fragrant balm, Cardinal flower, Funkia, Iris, Joe-Pye-weed, Ranunculus.

Shrubs. In properly made flower gardens and flower borders, the part played by shrubs is of great importance. They are permanent, and not only give a background of leafage against which the flowers of the border stand in striking relief, but they also render very great service in the way of screening the more delicate and softer textured plants just as a belt of woods serves as a windbreak to the orchard. But apart from this, the hardy

shrubs (and none others must be considered) are the mainstay of the floral display in early spring, the earliest opening their flowers even before the last frosts depart and keeping up a

FIG. 496. A border of perennials against a background of shrubs is one of the most effective and easily maintained of garden features.

succession till early summer. Shrubs that bloom thus early (before the leaves appear) must not be pruned back while dormant as that destroys the crop of flower buds. The rule for pruning all flowering shrubs is "prune after flowering." Shrubby plants offer a rich assortment of material for the American garden. A few selective suggestions are:

With very early flowers: Forsythia, Fragrant honeysuckle, Japan quince, Daphne. *With fragrant flowers:* White elder, Carolina Allspice, Fragrant amorpha, Golden currant, Daphne mezereum, Elder, Lilac, Mock-orange, Oleaster, Sheep-berry. *Blooming for 2 months or longer:* Shrubby cinquefoil, Kerria, Red root, Sweet pepper bush, St. Johnswort, Staggerbush. *Useful for cut flowers:* Double flowering almond, Golden currant, Deutzia, Lilac, Snowball, Spiraea, Hydrangea. *With attractive fruit:* Barberry, Burning bush, Indian currant, White kerria, Snowberry, Strawberry bush. *Evergreen:* Juniper, Dwarf pine, Mountain laurel, Mahonia, Pieris floribunda, Rhododendron. *For warm climates:* Carolina allspice, Camellia, Oleaster, Weigela. *For cold climates:* Button bush, Daphne, St. Johnswort, Sheepberry. *Drought-resisting:* Sand cherry, St. Johnswort, Sallow-thorn, Tamarisk. *For sunny places:* Carolina allspice, Bastard Indigo, Oleaster, Blue spiraea. *For shady places*: Andromeda, Mahonia, Mountain laurel, St. Johnswort, Alpine currant. *For heavy soils:* Shrubby cinquefoil, Lilac, Rose of Sharon, Thorn. *For light soil:* Red bearberry, Sand cherry, St. Andrew's cross, St. Johnswort. *For rocky places:* Creeping barberry, Red bearberry, Crowberry, Sweet fern. *For moist soil:* White alder, Mountain holly, Spice bush, Virginian willow. *For hedges (including some trees):* American arborvitae, Hemlock, Holly, Tartarian honeysuckle, Honey locust, California privet, Japanese quince, Norway spruce, Cockspur thorn, Deutzia, Spiraea, prunifolia, Thunberg's (Japanese) barberry, Lilac.

Trees are popularly considered to be merely giant shrubs, but there is a real and important difference: a tree leaves the ground with only one stem or trunk, whereas a shrub makes several growths, a cluster in fact. In practice, very low-growing trees are used in the same way as shrubs, and in nurseries are often so called. *Trees with showy fruits:* Cucumber tree, American holly, Mountain ash, Staghorn sumac. *With ornamental foliage:* Chinese angelica tree, Catalpa, Kentucky coffee tree, Honey locust, Pawpaw. *With large individual flowers:* Flowering dogwood, Gordonia, Magnolia, Tulip-tree, American pawpaw. *With small flowers in quantity*: Catalpa, Golden chain, Giant laurel, Japanese lilac, Red maple, Yellow wood. *With beautiful autumn foliage:* Sugar maple, White oak, Pepperidge, Sassafras, Sweet gum, Maidenhair tree, Tulip tree. *With fragrant flowers:* American linden (basswood), Black locust, Magnolia, Yellowwood.

Vines are trailing and climbing plants that clamber over a support. They may be hard, woody and permanent, spreading over more space each year, or herbaceous. Of the latter some are annual, others have permanent roots, so that although they die down to the ground at the end of each year they make new growths the next the same as other herbaceous perennials. *With showy flowers:* Clematis, Honeysuckle, Trumpet creeper, Wistaria, Climbing roses, Coboea, Moonflower, Morning glory, Perennial pea. *With attractive foliage:* Actinidia, Akebia, Boston ivy, Evergreen bittersweet, Dutchman's pipe; Japanese hop, Silk vine. *Annual:* Fire bean, Balloon vine, Canary bird flower, Maurandia, Ipomoea, Thunbergia. *Perennial:* Scarlet clematis, Ground nut, Cinnamon vine, Common hop, Butterfly pea, Perennial pea. *With fragrant flowers:* Actinidia Akebia, Cinnamon vine, Ground nut, Hall's honeysuckle, Silk vine. *Blooming four or more weeks:* Clematis viorna, Coboea scandens, Hall's honeysuckle, Morning glory, Perennial pea, Trumpet creeper. *Woody:* Bittersweet, Akebia, Matrimony vine, Silk vine, trumpet creeper, Wistaria, Climbing roses.

Special groups of plants may be made up to fit special purposes, thus: *Hardy bulbs* (to be planted out doors in fall): Crocus, Daffodil, Hyacinth, Jonquil, Narcissus, Tulip, Crown imperial, Glory-of-the-snow, Grape hyacinth (Pearls of Spain), Snowdrops,

Snowflake, Puschkinia, Lily, Colchicum, Scilla, Anemone, Ranunculus.

Bulbs, rhizomes, and tubers (for spring planting, mostly tender): Gladiolus, Montbretia, Tritonia, Zephyranthes, Tigridia, Dahlia, Galtonia (Hyacinthus candicans), Hyacinth squill, Ismene, Tuberous begonia, Canna, Elephant's ear, Lily-of-the-valley, Tuberose.

Aquatic or bog plants: Cardinal flower, Blue flag, Pitcher plant, Swamp pink, Water lily, American lotus, Golden club, Marsh marigold, Buck bean, Arrow head, Water arum, Bur-reed, Nelumbo, Pickerel weed, Water hemlock, Indian water rice, Turtle head, Cat tail.

Alpine and rock garden plants: Baby's breath, Blue bells, Columbine, Daphne, Foxglove, Gas plant, Golden tuft, Moss pink, Iceland poppy, Saxifrage, Swan River daisy, Linaria, Harebell, Alpine poppy, Rock cress, Mountain laurel, Anemone, Bunch berry, Easter bell, Blazing star, Catchfly, Stonecrop.

Window garden plants. Easy to grow: Abutilon, Begonia, Calla, Cyclamen, Fuchsia, Geranium, Heliotrope, Oxalis, Primrose, Rubber plant. *To transplant from the garden:* Ageratum, Abutilon, Alyssum, Begonia, Candytuft, Coleus, Fuchsia, Geranium, Heliotrope, Lobelia. *That stand neglect:* Agave, Begonia, Calla, Chinese primrose, Rubber plant, Cocos, Cyclamen, Geranium, Grevillea, Livistonia. *Vines:* Asparagus (plumosus and sprengeri) Ground ivy, Honey bell, Kenilworth ivy, Moneywort, Smilax, Periwinkle, Wandering Jew, White cup. *Window garden bulbs:* Tuberous begonia, Crocus, Cyclamen, Freesia, Hyacinth, Spanish iris, Narcissus, Oxalis, Tulip. *For hanging baskets:* Artillery plant, Alyssum, Centaurea, Cerastium, Dracaena, Lobelia, Maurandia, Nasturtium, Periwinkle, Wandering Jew.

SOIL MANAGEMENT. The majority of flower gardens on farms are made on soils just as they happen to be, often without as much preparation as is given an equal area in cereals, hay or vegetables. While some plants will thrive under almost any and all soil conditions, the great majority require that at least something be done to make their home congenial. In some cases (for instance, wild azalea, mountain laurel and rhododendron) this is imperative; they must have soil similar to that in which they grow in the woods. These particular sorts cannot endure lime in any form in the soil.

Except for bog and other water-loving plants, the soil should be thoroughly drained. A well-drained soil is warmer and "sweeter" than an undrained one. It is immaterial whether the soil be naturally or artificially drained, so long as excess water passes away in a reasonable time. For most plants the soil should contain ample supplies of vegetable matter. This is usually easiest secured by digging or plowing under liberal quantities of well-decayed stable manure. For a small area, leaf mold from the woods may be used, especially for growing plants that are to be transplanted from the woods. For house

FIG. 497. Vines soften the outlines of a house, shade it from the sun and give it a delightful air of permanence and right-to-be-there.

plants and for top-dressings, soil from a compost heap is excellent.

Making a compost pile. Such soil is made by piling sod (bottom up) and manure in alternate layers, adding liberal sprinklings of lime and ground phosphate rock as the pile is built and leaving it to decay slowly for a year or longer. It is a good plan to build such piles upon the weeds, stalks, leaves and other vegetable waste of garden and household—any stuff that has not been or cannot be worked over to better profit by domestic animals. Thus it is forced to decay and become valuable as plant food. After the pile (preferably made in spring when the grass is 3 to 6 inches tall) has stood for say, 6 months, it should be cut into up-and-down slices with a sharp spade and made into a new pile. By throwing the outside part of the first pile into the centre of the second and vice versa a better mixture and more even rotting are secured.

Light and heavy soils. Clayey and other heavy soils are easily lightened and made more congenial by mixing in sand, sifted coal ashes, leaf mold and well decayed manure—whichever is easy to get. All may be added together if available. Digging or plowing in late autumn and leaving the furrows or the clods rough just as turned up is also excellent because the action of frost will break these clods into fine particles. Another good thing is to apply fresh lime dust in spring before the rough lumps are harrowed or raked or, if spring plowed or dug, after the soil has been turned.

Sandy or light soils should be liberally dressed with well decayed manure, kept co-

ered as much as possible with plant growth, and worked less and shallower than heavier soils during hot weather.

LAYING OUT THE GROUND. To get the most pleasing effects, a flower garden should be merely an incident in the general plan of the home grounds. The idea should be first to develop a picture with the lawn as the canvas, the house as the most important feature and the trees, shrubbery and other plants as the frame; flowers are then massed in the foreground of such plantings. So planned there will be a natural landscape effect which is impossible if stiff rows and geometrical beds of flowers are used. To secure best results, maintain an open centre to the place, keep the ornamental plantings well to the sides, and steer clear of scattered effects. A flower bed on a lawn is less effective than the same or even a smaller quantity of bloom in the border. Besides it is a mud hole half the year! The position flowering or otherwise ornamental plants occupy is of more consequence than the kinds of plants used.

When the land has been prepared, the areas to be planted may be marked out with stakes. Generally better effects will be gained by avoiding straight lines. The best way to do this is by using an old, limp rope to mark the border. When the line has been laid down in pleasing curves the stakes are placed, the lawn is seeded and rolled and the border planted with shrubbery, perennials, etc.

Whenever hardy stock can be procured fully ripe, it is advisable to plant early in the fall; herbaceous plants are best handled even earlier—in late summer. The work is then out of the way and will not interfere with the spring rush of farm work. Plants not fully ripe and those more or less tender or difficult to transplant had best be planted in spring as soon as they can be procured and the ground has settled. Always head back bushes as soon as planted to balance the injury to the roots that is almost sure to occur even with the best care. Best results will be gained by planting several small-size shrubs of a kind thickly, and thinning them out as they grow large. The spaces between the large plants may be filled the first few years with hardy annuals and bulbs.

THE LAWN. To make a good lawn, first see that the grade is right—avoid steepness anywhere. Have the soil deeply- and well-prepared as the lastingness of the lawn depends much on the conditions at the start. The deeper the roots can be made to go the better because the plants will thus be able to stand drought and severe winters. Tile or natural drainage is essential to success. Abundant applications of well-rotted manure well worked into the soil also help to retain moisture. After the first season liberal annual dressings of manure in late fall, or of commercial fertilizer in the spring should keep the lawn in good shape. An objection to stable manure is the presence of weed seeds. Perhaps the best all-around fertilizer is 300 to 400 pounds of ground bone to the acre sown broadcast in early spring. Should the grass look yellow in spots, nitrate of soda will usually make it green again—200 to 300 pounds to the acre during the growing season. Good grasses for the North are Kentucky and Canadian bluegrass; for the South, Bermuda grass. Other grasses often used are red top, timothy, Rhode Island bent, and rough-stalked meadow grass (for shady places). Bluegrass needs a sweet soil and on coastal, sandy, arid soils fescue and red top will be better. Use only recleaned seed, about 3 to 5 bushels per acre (figuring about 20 pounds to the bushel).

Seeding should be done in cool weather when the soil is moist and the air still. Preferably the land should be prepared in late summer or early fall, allowed to settle, and sown in late September or October unless there has been much grading and filling, when it can wait till early spring. The first season there will be quantities of weeds. Only the bad perennials need be pulled out; the others may be killed by mowing or later choked out by the grass. Mowing should begin as soon as the grass is tall enough and be repeated as often as necessary. Frequent mowings are

FIG. 498. An example of poor taste, poor design, poor proportions, lack of fitness, and failure to let nature help in making the place in any way attractive.

FIG. 499. The home of the late "Jo Wing" of Ohio, is a farm house that is all that could be wished, inside and out, to look at and to live in. Plants are one of its charms.

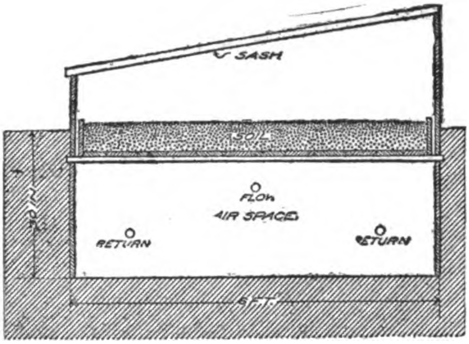


FIG. 500. When a greenhouse is maintained it can often supply heat for a hotbed as shown here. This does away with all manure, labor of filling, etc., and permits the bed to be prepared at any time of year.

easier and best because the cut grass does not need to be raked away to save the grass from injury; short mowings work down and form a mulch among the grass blades.

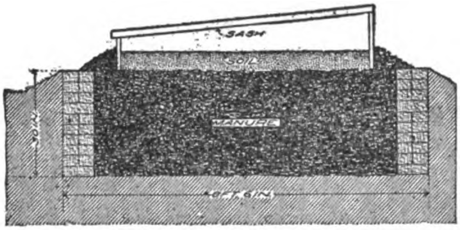


FIG. 501. A permanent hotbed with brick or concrete foundation is a good investment wherever plants—vegetables or flowers—are raised each year for either sale or pleasure. Compare Figs. 439 and 440.

Growing Plants from Seeds

All annual and biennial flowers and many perennials are easily grown from seeds. Some of them being slow to germinate, or slow to grow, should be started indoors, in a hotbed or a greenhouse; others may be sown out of doors. There is no rule that will cover all cases or all parts of the country. Reliance must be placed upon seedsmen's directions which are almost always printed on the packets. Those that require a long season or are slow to germinate can be grown nearly as well in the dwelling as in a hotbed or a greenhouse provided the temperature, moisture and light are right. In most cases the warmth and moisture are better in the kitchen than in any other room. While the seeds are sprouting no light is needed, but as soon as growth starts it is. If there is too much light and if the air is too dry, the seedbox may be covered with newspaper. It is better to prevent drying out in this way than to apply water to small seeds except by standing the seedbox in a tub so the water may come through the bottom and work its way up into the soil. When the surface begins to look wet remove the box, and after allowing it to drain, replace it on the window sill or plant stand. When the wet look has disappeared from the surface in a day or two, put on newspaper to hold the moisture. This method of watering prevents caking of the surface.

Handling seed boxes. Flats need not be more than 2 inches deep and should have cracks or holes in the bottom for drainage. Only light, rich earth should be used to fill them to within half an inch of the top. To make such soil, use black leaf mold from the woods, or light sandy soil mixed with an equal bulk of stable manure that is so rotted it looks like leaf mold. Lightness and sponginess is the first requisite, for tiny seeds will not sprout in heavy soil. Always the soil should be firmed and leveled with a smooth board or a brick before sowing. Whether the seed be sown in little drills or broadcast is immaterial provided it be sown thinly enough. Better too few than too many plantlets. Judgment alone is the guide here. Instead of throwing earth on the seeds, it is better to use a kitchen or similar sieve to scatter a thin dusting of soil, just enough to cover the seeds, which must then be gently pressed down again with the board. For the great majority of seeds the night temperature during germination should be about 60 degrees, that during the day 70. The time to do this work will vary with the kind of plant and the latitude from January to March, slow-growing ones being started earlier than quick-growing and

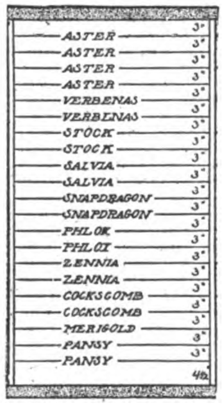


FIG. 502. One sash of the hotbed planted as shown will provide all the flowers you can use all summer.

those in southern states earlier than those in northern.

After the seedlings appear great care must be exercised to have the surface of the soil dry, because otherwise tiny fungous plants are likely to attack the little plants and kill them. This damping-off as it is called, when once it starts, may kill all the plants in 48 hours. A spray of copper sulphate in water (an ounce to the gallon) may kill it without hurting the plants, but far better keep the surface dry and well aired than rely on any remedy for bad management. When the seedlings are large enough to be lifted on the end of a tooth pick the larger and healthy ones may be transplanted to clean soil in another box. This "pricking out" is necessary any way soon after the "true leaves" appear above the "seed leaves" so no time is lost. In a few weeks the pricked-out plants will have become large enough to be set singly in 2- or 2½-inch pots or transplanted to other boxes 2 to 3 inches apart. From the pots they may be shifted to larger sizes, an inch larger with each shift, or set in the open ground. In this way as many plants may be grown from a 5-cent or 10-cent packet of seeds as would cost $5 to $10 if bought from florists.

How to grow seedlings. The following index numbers refer to the condensed directions for the culture of popular plants found on this and the following pages. These are arranged by groups of plants that require similar treatment. Except when otherwise specified, the seeds are to be sown in shallow boxes of light soil, covered not more than 4 times their diameter with light soil pressed down firmly both before sowing and after being covered with earth, watered either as already described or with a very fine spray, kept from drying out, and transplanted when the second or third true leaf has formed.

Abutilon	9	Convolvulus	6	Kudzu vine	14	Poppy, hardy	14
Achilles	14	Coreopsis	14	Lantana	9	Portulacca	6
Ageratum	6	Cosmos	1	Larkspur, annual	13	Primula, tender	2
Alyssum	6	Cowslip	3	Lathyrus latifolius	14	" hardy	3
" perennial	14	Cuphea	1	Lavender	14	Pyrethrum, hardy	14
Amaranthus	1	Cyclamen	2	Lemon verbena	9	" golden leaved	15
Anchusa	14	Cypress vine	6	Linum	13	Rhodanthe	8
Anemone	14	Dahlia	10	Lobelia, annual	15	Ricinus	6
Antirrhinum	1	Datura	6	" hardy	14	Rocket	14
Aquilegia	14	Delphinium	14	Lupinus	13	Rose, monthly	7
Aristolochia	14	Dianthus, annual	13	Lychnis	14	" hardy	14
Aster	1	" hardy	14	Mallow	6	Rudbeckia, annual	13
Balloon vine	6	Digitalis	14	Marigold	6	Salpiglossis	1
Balsam	1	Dolichos	6	Marvel-of-Peru	6	Salvia	1
Bartonia	13	Edelweiss	14	Mesembryanthemum	6	Scabiosa	6
Begonia	11	Eschscholtzia	13	Mignonette	13	" perennial	14
Bellis	3	Euphorbia	6	Mimosa	4	Schizanthus	6
Bignonia	14	Fuchsia	9	Mimulus	4	Silene	6
Calandrina	16	Gaillardia	6	Moon flower	6	Smilax	9
Calceolaria	2	" perennial	14	Morning glory	6	Stevia	1
Calendula	6	Geranium	9	Myosotis	3	Stock, annual	1
Calliopsis	6	Globe amaranth	8	Nasturtium	6	" biennial	7
Campanula	14	Gloxinia	11	Nicotiana	4	Stokesia	14
Canary vine	6	Godetia	13	Nigella	13	Sunflower	6
Candytuft	13	Grevillea	9	Oenothera	1	Swainsona	11
" hardy	14	Gypsophila	6	Oxalis	6	Sweet pea	5
Canna	10	" hardy	14	Pæonia	14	Sweet sultan	6
Canterbury bell	14	Heliotrope	9	Pansy	3	Sweet William	14
Carnation	12	Heuchera	6	Passion flower	9	Tritoma	10
Celastrus	14	Hollyhock, hardy	14	Pelargonium	9	Tropæolum	6
Celosia	1	" annual	1	Pennisetum	14	Valerian	14
Centaurea	13	Honeysuckle	14	Petunia	4	Verbena	1
Chrysanthemum	13	Humulus	6	Phlox, annual	6	Vinca	9
" perennial	12	Hyacinthus	10	" hardy	14	Violet	3
Clarkia	13	Ice plant	1	Physalis	1	Virginia stock	13
Clematis	14	Impatiens	9	Pink, annual	13	Viscaria	13
Cobœa	4	Incarvillea	13	" hardy	14	Wallflower	14
Cockscomb	1	Ipomoea	6	Platycodon	14	Wistaria	14
Coleus	4	Ivy, English	14	Polyanthus	3	Zinnia	6
		" Kenilworth	14	Poppy, annual	16		

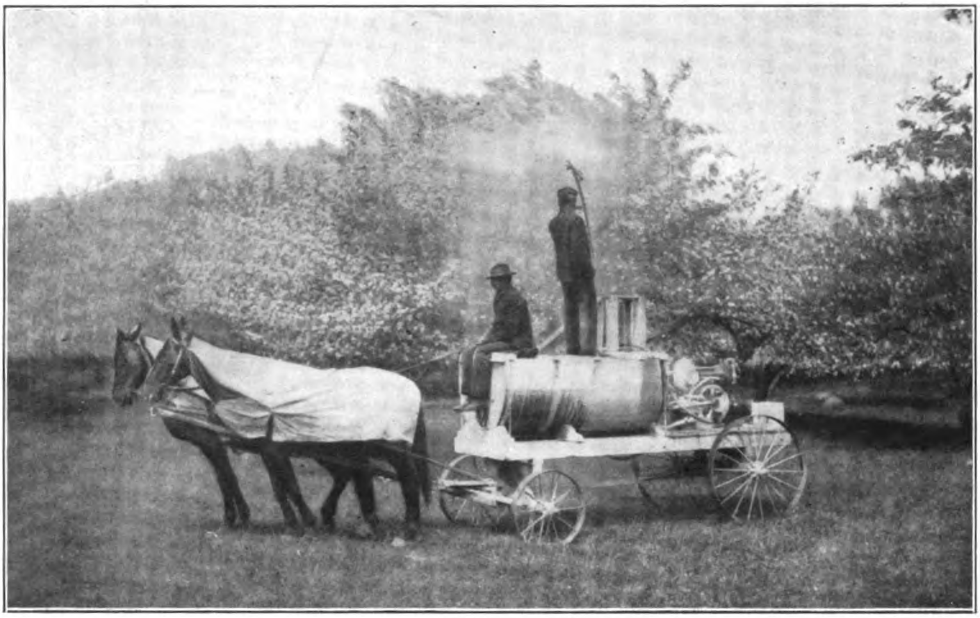
Directions for growing the above-listed plants. The index numbers refer to the following paragraphs.

1. Sow during early spring in greenhouse, hotbed, or sunny window. Maintain 60 to 70 degrees. Transplant 1 inch apart in shallow boxes or into 2-inch pots. Plant out of doors after danger of frost has passed. Sowings may also be made out of doors when danger of frost has passed, but plants so produced will be later blooming.

2. Sow during spring or fall in sunny window, hotbed or greenhouse. Maintain 50- to 60-degree temperature. Scatter seed on the smooth, firm surface of the soil and dust a little finely sifted earth over it not deeper than barely to hide it. Transplant 1 inch apart in other boxes. When the plants begin to crowd shift to 2-inch pots and when the roots fill these pots shift to a larger size. Shift again and again as necessary till the plants are in 6- or 8-inch pots for flowering.

3. For earliest bloom sow during autumn in well prepared fine soil. Transplant 2 inches apart in coldframe, which cover with a straw mat in coldest weather. For later flowers sow in early spring. Maintain about 60 degrees temperature. Transplant 1 inch apart. In either case plant out of doors when frost leaves the ground. Best flowers are secured in moist loamy soil in partial shade.

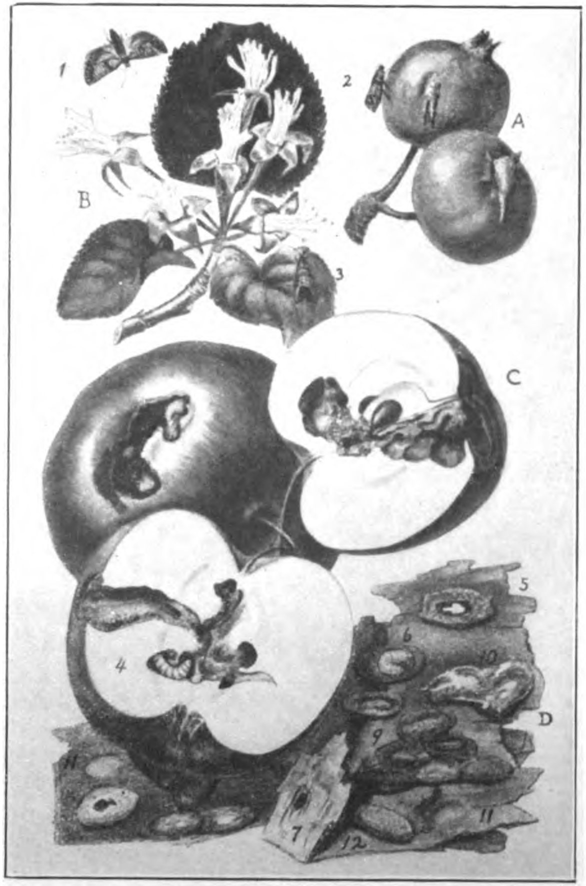
4. Use light soil in boxes placed, after sowing, in window, hotbed, or greenhouse. Keep temperature between 60 and 70. Transplant seedlings 1 inch apart in other boxes when the second or third leaf has formed. Plant out of



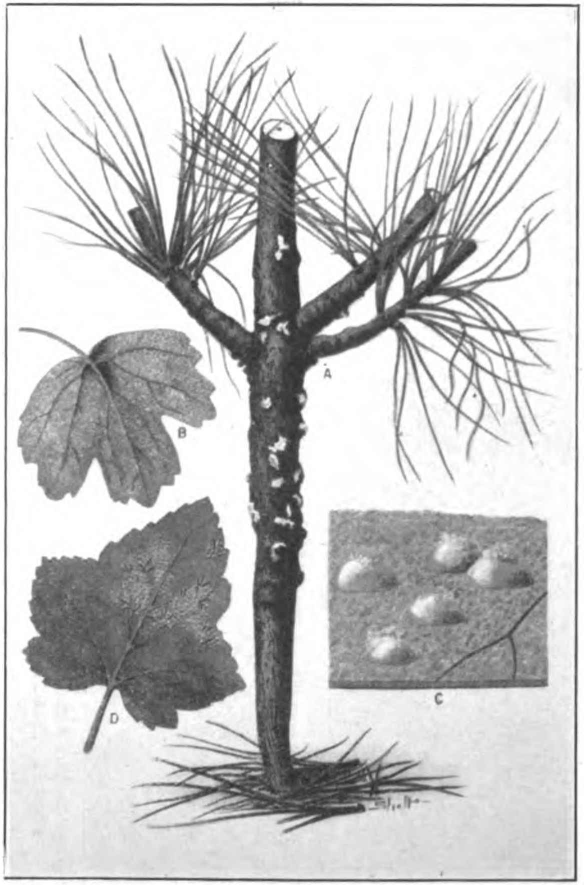
Modern spraying methods and materials offer protection against nearly every plant enemy known. But their use demands intelligence and thoroughness

Even the mysterious dangers of climate and weather can be partially guarded against. Protecting an orchard by means of smudge or fire pots

FARMING IS CONTINUAL WARFARE. IN OVERCOMING HIS OBSTACLES AND CONQUERING HIS ENEMIES, THE FARMER ADDS NOT ONLY TO HIS PROFITS, BUT ALSO TO HIS CHARACTER



The codlin moth and its work. A, wormy apples; B, blossoms at the right stage for spraying; C, the worm's work; 1, 2, and 3, moths (adults); 4 and 6, worms; 7, hole made by woodpecker in seeking worm; 5 and 8-12, cocoons, most of these on piece of bark (D). (N. Y. State Department of Education, Bulletin 510)



The white pine blister rust. A, diseased tree with blisters broken open, spreading the disease to near-by currants and gooseberries; B, early summer stage on under side of currant leaf; C, same as B much enlarged; D, late summer stage on upper side of currant leaf, whence it spreads back to white pines. (Farmers' Bulletin 742)

TWO COMMON AND DESTRUCTIVE PESTS REPRESENTATIVE OF THE INSECT ENEMIES AND THE DISEASES AGAINST WHICH EVERY FARMER MUST BE PREPARED TO FIGHT

doors when frost danger has passed or for large specimen plants in flower pots into 12-inch pots for shifting into larger ones when the roots need more room.

5. Sow out of doors in early spring the earlier the better to remain, the soil being deeply prepared. For best flowers thin seedlings to 6 inches or more apart. Moist, loamy soil is best. In light soils make a furrow 4 or 5 inches deep but cover the seeds only 1 inch. As the seedlings grow, fill the trench and form a ridge of earth with the plants in the middle. For longest season of bloom keep flowers from going to seed.

6. Sow out of doors in well pulverized light soil after frost danger has passed. Thin seedlings so the plants do not crowd. For early flowers sow in boxes in the window, hotbed or greenhouse, transplanting to other boxes when the second or third true leaf has formed and set out of doors after frost danger is over.

7. Sow in light soil in hotbed or greenhouse. Transplant to other boxes when in second or third leaf. Plant out of doors after frost danger has passed. Early sowings will bloom the first season, later ones not till the next year. In cold climates the later sown plants must be taken up, potted and kept in a cool greenhouse or heeled in during winter in cold frames well protected in coldest weather. The latest sowings may be made in May or June out of doors.

8. Sow out doors after frost danger has passed. Thin the plants to prevent crowding. For earliest flowers sow in shallow box in hotbed or greenhouse. Keep temperature about 70. Transplant to other boxes when second or third leaf has formed. For "everlasting flowers" cut when the buds are only about half opened and hang in a dry, dark place heads downward, till thoroughly dry.

9. Sow in shallow boxes of light soil placed in greenhouse, hotbed or dwelling-house window with temperature of 65. Put seeds at depth of four times their size and make soil firm. Transplant to 1 inch apart in other boxes when two or three leaves have formed. Keep moist by fine spray. Shift on in pots successively as they grow larger, or plant outdoors after danger of frost has passed.

10. Sow in light soil in window, hotbed or greenhouse. Keep temperature about 65. When second or third leaf has formed transplant into other boxes; and, after frost danger is over, to the garden. In fall, before freezing weather, lift roots and store in sand in cool dry cellar. Make outdoor sowings after frosty weather has passed.

11. Use light soil in shallow boxes in window, hotbed or greenhouse. Keep temperature about 70. Do not cover seeds; merely dust on surface, press with a smooth board and water with a very fine spray that does not disturb the surface. Keep covered with a pane of glass or newspaper, a little space for ventilation in the former case. Keep in partial shade till second or third leaves have formed, then transplant to other boxes and later to pots.

12. Sow indoors in shallow boxes. Keep temperature at 60 degrees, sprinkle with fine spray and prevent drying of soil. Transplant when second or third leaf has formed 1 inch apart. When 1 to 2 inches high transplant to 2-or 2½-inch pots. For specimen plants in pots shift to larger pots when plants need more root space. For use out doors transplant to open ground when weather is settled. Such plants will form flowering clumps before the season closes.

13. Sow out of doors when settled weather comes in spring, and at intervals of say 2 weeks through summer. For earliest flowers use sunny window, hotbeds or greenhouse. Keep temperature about 60. Transplant when in second or third leaf into other boxes and set in open ground after frost has passed.

14. Sow out of doors after weather becomes settled in finely pulverized soil. Thin seedlings to prevent crowding. Transplant to permanent places when large enough. The earlier this is done the better established the plants become before winter. If desired, sowings may be made in late summer or early fall and the plants carried over winter in a cold-frame for transplanting to permanent position in spring.

15. For large plants for spring planting, sow seed in light soil in early January in a sunny window, hotbed or greenhouse with temperature kept at about 60 degrees. Transplant 1 inch apart to similar boxes when second or third leaf has formed and again when large enough for 2- or 2½-inch pots. Set in the open when frost danger has passed.

16. After the weather has become settled, sow in the open ground in well-fined soil, where the plants are to flower, because transplanting is very difficult. Thin out carefully so that the remaining plants are not disturbed. Where very close together better use a sharp knife or a scissors to cut out the undesired plants so as to prevent disturbing the ones to remain. To get successions of bloom make 2 or 3 sowings during spring and summer.

Propagation of Plants

From cuttings. The great advantage of propagation by cuttings is that the same variety of plant as the one that gives the cuttings can be reproduced indefinitely. Thus friends may exchange "slips" of particularly admired and rare plants and be sure of what they are getting. Growing many kinds of plants from cuttings is easier than growing them from seeds. With these it is not necessary to have the equipment used by professionals but it is essential to have the conditions of temperature, moisture, and, generally, shade during the sunny part of the day just right as well as the making of the cuttings themselves. "Green wood" cuttings should have reached a development that will allow their being snapped instead of "kneed" when bent. Reduce to 1 or 2 leaves. Thus they lose little water by transpiration while the lower ends are developing roots. While cuttings that bend will take root they are generally slower than those that break clean off; practice soon enables one to recognize the best condition. With shrubby plants such as Roses and Azaleas the wood may be older.

The simplest method of handling cuttings is to use a soup plate or a large saucer filled with sand kept wet as long as the cuttings are in it. The cuttings may lie with their butts toward the centre like the spokes of a wheel and far enough apart so they do not touch. A warm, light room will generally give better results than a cool, shady one. It is essential that the sand be kept saturated with water until the cuttings have developed roots. So treated probably 75 to 90 per cent will take root in a temperature of not less than 65 nor more than 95. The best range is 75 to 80 degrees in sunlight. Verbena, Fuchsia, Heliotrope and similar plants will root within 10 days; Roses, Carnations, and other semi-woody plants in 3 or 4 weeks. As soon as well rooted they should be potted in light soil in 2- or 3-inch pots and kept carefully shaded with wetted newspapers for 3 or 4 days from about 9 to 4 o'clock when the sunlight is strong.

FIG. 503. Geranium cuttings growing in the pot in which they were rooted.

Layering is a very simple method of propagating many shrubby and semi-shrubby plants like Virginia creeper and

FIG. 504. Making a whip graft, suitable for roots or woody stems. *a* stock and *b* scion, prepared; *c* the graft made and ready to be tied with soft cord or raffia, and, if possible, covered with grafting wax to check evaporation.

Carnations. The only difference between a cutting or slip and a layer is that the former is separated from the parent plant before being rooted whereas the latter continues attached until after it has rooted. In many cases the wood may be fully mature in others only half ripe. All that is necessary is to remove the leaves for several inches on the stem, peg this part down to hold it firmly and then cover with earth kept moist preferably by mulching or shading. Rooting is often hastened by cutting a slit, a notch, or a girdle through part of the bark. Such cuts are best made on the upper side of the shoot to prevent breakage when bent. In a few weeks the roots will have formed and the plant may be separated and planted.

Division is practised with hardy perennials such as Phlox and Bleeding-heart which form large clumps and with similar shrubs—Barberry, Mockorange, and Snowball. Late in the fall or early in spring before growth starts, the whole clump is dug up and cut with a sharp spade or hachet into as many parts as desired and each part is replanted in a new place. Finer division is often practised with a knife on Cannas and Peonies especially when a large number of new plants is desired. In such cases, too, the plants should be dormant when the work is done and each piece should carry at least one "eye" or bud and some roots. Tender plants like Cannas are best started in the house; hardy ones like the Peony will do almost as well out of doors.

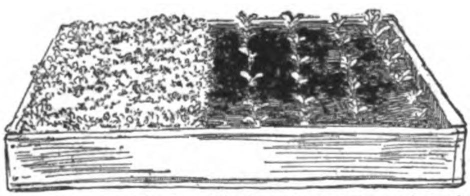


FIG. 505. A flat of seedlings as they grow (*left half*) and after being "pricked out" (*right half*)

FIG. 506. A leaf cutting of begonia

Transplanting Young Plants

Young plants grown from seeds, cuttings, or layers need special care in their handling after roots have been made. They must be given more room. The operation of transplanting presupposes fine soil and careful setting. Care must be taken to save all the roots possible and in many cases to cut off a considerable portion of the top so as to balance the unavoidable loss of roots and thus give the plants a better chance to grow. Much may be gained in out door transplanting, especially late in the season, if the work is done in cloudy or even rainy weather or in the evening, because the losses of water from the plants are smaller than during sunny weather. Shading in sunny weather for a few days often contributes to success. For doing ordinary transplanting the dibber or the trowel is most often used but in either case care must be exercised to press the earth closely against all the roots, otherwise they may "hang" in an air chamber and never develop, and the plant may die. (*a* Fig. 508).

Successful Plant Management

After the seeds have been sown or the plants transplanted to their permanent quarters in the garden great care should be taken to prevent their suffering from weed growth among them and from lack of water. By stirring the soil frequently with a hand weeder or a garden rake the surface will be kept so unsettled that weed seedlings will not have a chance to grow, and evaporation will be checked. It is far more satisfactory to keep water in the soil by thus maintaining a loose layer of dusty earth than to apply it with watering pot or hose, for such applications are almost sure to be far too small to do any good. Indeed, they often do positive harm because they encourage the roots to form near the surface instead of going deep into the soil. Better to withhold water 2 to 4 weeks until the plants again begin to wilt and then, preferably in the evening, drench the soil to the depth of a foot or more, than to apply an equal amount of water in a succession of daily

dribbles. As soon after such a drenching as the surface begins to look dryish, possibly the following morning, break the crust up finely with a hand weeder or a rake so as to make a new dust layer which will act like a blanket to keep moisture in the soil below. This is the most important work among all kinds of flowers and vegetables until the plants shade the ground. Removal of weeds, while necessary, is of secondary importance; it may be accomplished by mulching with old manure, litter, marsh hay, or other material preferably free from weed seeds.

FIG. 507. The beneficial effect of transplanting on tomatoes, which is duplicated in the case of many flowers. The plant at the left was not moved, the next was lifted once, and that on the right, twice.

Choosing Plants that Really Fit

On a new place it is advisable to plant the first year for immediate effect. For this purpose many kinds of annual flowers will make a wonderful display the first season—Alyssum, Asters, Calliopsis, Coboea, Cosmos, Gourds, Wild cucumber, Morning glory, Moon flower, Marigold, Four-o'clock, Nasturtium, Petunia, Sunflower, Poppy, Portulacca, Castor oil bean, Salvia, and Verbena. Along with these should be planted biennials, hardy perennials, and quick-growing shrubs and trees. But the quicker-growing and shorter-lived of these should be considered as temporary only, main reliance being placed on the slow-maturing, choice plants whether hardy perennials, woody vines, shrubs or trees, the idea being to remove the quick-growing and usually inferior plants when the others need the space.

Best results will follow the plan in which the choice, slow-growing things are placed first and the quicker-growing ones used merely to fill in. The choicer plants should never be allowed to suffer from being crowded by the temporary plantings, nor should they be distorted by shearing, heading back or other form of pruning that might prevent development of their natural beauty. Many shrubs and trees are too erect and stiff to be pleasing while young, but attain character as they grow older. So the pruning shears and the knife should be used with great caution and hesitancy.

Where to place trees. The trees may be so arranged and placed as to act as a windbreak and thus enhance the comfort of the home. For this purpose they should be at right angles to the prevailing winter wind. Both deciduous and evergreen trees should be included. Excellent species of the former are Sugar maple, Eucalyptus, Pepper tree, Cabbage palmetto, Basswood, Russian mulberry; of the latter, Norway spruce, Hemlock, Monterey cypress and Monterey pine. By placing the deciduous trees on the windward side of the evergreens they break the force of the wind and protect the latter from becoming ragged.

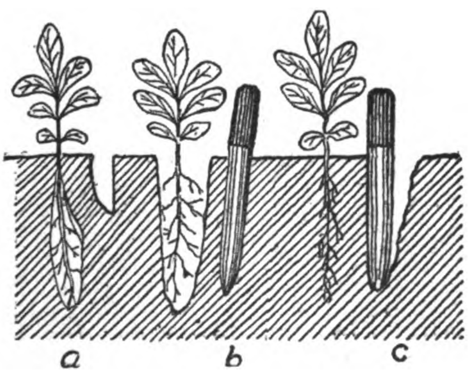


FIG. 508. In setting out a plant with a dibble don't crowd the earth over only at the top leaving the roots in an open space (*a*); instead, insert the plant; thrust the dibble in its whole length (*b*), then move it bodily toward the plant firming the soil around all the roots (*c*).

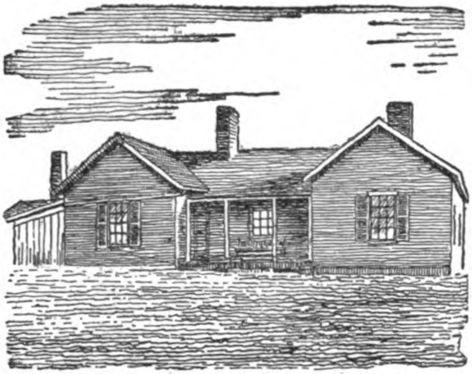


FIG. 509. A house as built, and, all too often, as lived in by people who don't know what they are missing

Where less protection is needed than these trees give, Austrian and Scotch pines are excellent with tall deciduous shrubs or low trees like Dogwood, Lilac, and Mockorange. These latter and even lower-growing shrubs will serve well to hide unsightly buildings such as barns. While such trees are growing, Sunflowers, Castor beans, Corn, Giant reed, and other tall growing annuals will serve for at least part of the summer; or a trellis covered with Morning glory, Hop, Coboea, and other quick-growing vines. For summer uses only, very striking screens may be made by planting Ailanthus or Paulownia only 2 or 3 feet apart and cutting them at the surface of the ground each spring so as to force the growth of new stems which will often grow 15 to 20 feet in a single summer and give a decidedly tropical effect.

Hedges that must be sheared to make them presentable are a nuisance; they demand too much work. To secure a good hedge prepare the soil deeply, set the plants very close and in a shallow trench, preferably alternately in double rows, and if erect-growing shrubs are chosen shear the plants each season after the first so as to form a wide inverted V, with a rounded top. This form will permit the lowest branches a chance to get light and will thus prevent to a large extent the dying of these branches as is always the case when hedges are trained with square tops and narrow bottoms. For tall hedges Norway spruce and Hemlock are excellent; lower and coarser ones are made with Scotch and Austrian pine; Monterey cypress is popular in California; low hedges are made from Japan quince, Privet, and various dwarf evergreens; edgings of Box are popular for borders of walks. Of all shrubs that grow less than 8 feet tall, the Japanese barberry makes the most beautiful hedge with the least work. It needs no pruning except the occasional shortening of a long, stray branch.

BORDERS VERSUS BEDS. Much more pleasure will usually be taken and less work required when plants are arranged in "borders" rather than in "beds." The beds make breaks in the lawn and during a large part of each year are unsightly because nothing is to be seen in them but bare earth. Borders, as their name implies, are continuous plantings around the margins of the lawn and beside walks, drives, and buildings. They may consist of one class of plants as shrubs, hardy perennials, annuals, or of mixed plantings. These last are generally the most satisfactory. In making a border most pleasure and least disappointment are likely to result (1) when hardy plants alone are considered; (2) when the choice is confined to those one likes best; (3) when those suited to climate and soil are chosen, and (4) when the plants are suited to the place they are planted.

The new border. Always have the soil of a border or bed well drained, and fertile, though not necessarily rich, keeping it so by annual dressings of manure. After plow-

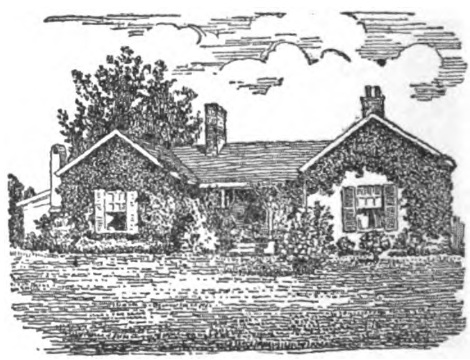


FIG. 510. The same house made permanently into a home by the use of a few flowers, shrubs, and vines—and a little judgment and care.

ing or spading it deeply enough to break any hardpan, set the plants irregularly so as to avoid stiffness and formality, except along the back which may be planted in a straight line. In a large border of shrubs, a horse cultivator may be used for a year or two where the plants are set 2 to 5 feet or more apart, but generally hand wheel-hoes or smaller hand tools alone may be used.

One effective way to prevent weed trouble for the first year or two is to sow quick-growing hardy annuals broadcast among the transplanted plants. For this purpose Sunflowers, Morning glories, Poppies, Zinnias, Marigolds, Four-o'clocks, Cosmos, and Amaranths are among the best. They should all be sown as early as possible after the permanent plantings have been made so as to get ahead of the weeds, or they may be started in the house and transplanted. They will not only prevent weed troubles but will take away the bare appearance the first few years.

After maintenance. After the border once becomes filled and the plants established, the less digging the better; tillage should then be only surface stirring so as to avoid damage to the roots and crowns; a heavy mulch of well decayed manure each fall will do much to keep down weed growth, maintain fertility and the necessary supply of humus. In planting, place large shrubs like Lilac and Mockorange 5 or 6 feet apart; smaller ones like Japan quince and Spirea 3 or 4; vigorous herbaceous perennials like Peony 3; Bleeding heart and Larkspur 1 to 2; and for the first 2 or 3 years use low-growing annuals like Asters, Petunias, and Verbenas in front, with tall-growing kinds like Summer cypress, Salvia, and Scarlet runner bean among them.

The beauty of a border may be enhanced by making its general outline irregular and wavy especially around the boundaries of the area so there may be bulges and indentations, parts somewhat hidden and others prominent. By varying the plantings so the height of the plants will be tall in some places and low in others the effect may also be improved. Then by having the shrubs and hardy perennials in large clumps that bloom at different seasons, there will always be some one plant of interest where the varieties are well chosen and placed so as not to blossom together. By good choice and arrangement along these lines, a very effective border may be made in less than 2 yards at the widest part and only a foot or two at the narrowest, yet giving the suggestion that a much larger space has been utilized.

Planting a bed. The same kind of preparation of the soil as for the border will apply to the flower bed. Then set the plants close enough to cover the ground completely. The positions for flower beds are in angles around the house and on the inside angles where walks change direction. Sometimes they look well beside walks and drives, but their shapes should be such as fit the positions where they are placed. The more naturally a plant is allowed to develop the more pleasure it is likely to give. For cut flowers the plants should usually be set in straight rows near the vegetables they can there be given proper cultural care, and do not look so unsightly after being cut.

FIG. 511. The lawn should be a smooth, unbroken expanse. A well chosen border sets it off to perfection besides being itself a thing of beauty. A lawn spotted with fancy beds is an eyesore.

ANNUAL FLOWERS. Properly speaking, an annual is a plant that starts from a seed, produces flowers and seeds and dies in one season or a part of a season. By starting the seeds indoors early certain perennials such as Snapdragon, Pansy, and Chinese pink may be made to blossom the first year. The true biennials such as Canterbury bell, Linaria and Adlumia may be handled like annuals after the first year, the seed being allowed to fall and sow itself to make a succession of plants. In the latitude of New York and even farther north, the seeds of most annuals may be sown in the open ground after the weather becomes settled in mid May.

For extra early flowers of any annual, the seeds should be started very early in the house, the hotbed or the greenhouse. Successional sowings at intervals of 2 to 4 weeks will keep up the supply of flowers throughout the season, for unless the fading flowers and the seed-pods are picked off the plants will soon cease to bloom. Care is necessary with window-grown plants to prevent the earliest sowings from "drawing" or becoming leggy from lack of light. Unless this can be prevented it is better to wait until sowings may be made out of doors.

Hardy, semi-hardy, and tender annuals. Annuals are for convenience grouped under several heads according to their behavior in cold weather. The terms are relative; for

what may be tender in New England may be hardy in the Southern states. Hardy annuals such as Ageratum, Calendula, Calliopsis, Clarkia, Marigold, and Mignonette are those which may be grown without the aid of artificial heat. Generally they are sown in April or May where they are to stand during the season, though often they are started in small beds for transplanting when large enough. Some of them are so hardy that they are often started in the autumn and protected over winter in coldframes or under protectors of evergreen branches or leaves. Half-hardy and tender annuals require more heat than hardy ones to make the seeds germinate; the former such as Balsam, Petunia, Stocks, and Verbena will stand some frost, but the latter such as Coboea, Amaranthus, and Cockscomb will not stand any. None of these can be sown with safety out of doors until the weather has become settled; for the former about May 1 to 15; for the latter about June 1. It is better to start the tender ones indoors and transplant the seedlings. Some kinds do not transplant well; they should therefore be sown where they are to bloom. Among these are California poppy, Bartonia, Dwarf convolvulus, Lupines, Malope, Venus' looking glass, and common annual Poppies.

Prepare the seedbed with a steel rake and then use a board to firm the soil by walking on it. After the seed has been sown and covered about 4 times its diameter with fine soil the board should be used again. This insures a supply of moisture near the surface.

BULBS, TUBERS, AND SIMILAR PLANTS. Properly speaking, a bulb is a large dormant bud composed of scales either overlapping as in the Lily or continuous as in the Onion, with a more or less central embryo stem. A corm resembles a bulb externally but is solid; Gladiolus and Crocus are examples. Tubers such as Irish potatoes and Dahlias are solid underground parts with buds or "eyes." So far as the management in the garden is concerned they may be grouped together, but separated on the basis of their behavior with respect to frost: Some are hardy, others tender. Those that blossom in early spring—Crocus, Narcissus, Tulips, Hyacinth, etc.—are often called Holland or Dutch bulbs because they come largely from Holland. The summer bloomers come from many parts of the world. They include the Lilies. The hardy bulbs give best results when planted in the fall. Any time after the tops have died down and before the ground freezes hard for the winter will do, but usually the ground is occupied by other plants until October or even later and in many cases imported bulbs cannot be secured until November. Good results are often secured even after hard freezing, especially where the ground is kept from freezing deeply by a heavy mulch of manure or litter until after the bulbs are planted. The reasons for fall planting are that the bulbs form roots during winter and are thus ready to begin growth in spring; even when they can be purchased in spring they do not give satisfactory results the season they are planted. After the ground is frozen give a heavy mulch of marsh hay, corn stalks or clean straw to prevent alternate thawing and freezing during winter. If mulched before freezing there is danger that mice will make their nests therein and eat all the bulbs before spring.

Bulbs of all kinds do best in well-drained, deep, rich soil. When there is no choice but a damp area in which to plant, the effect of the dampness may be reduced by raising the bed 6 to 18 inches and by placing a double handful of sand at the bottom of the hole in which the bulb is to be planted, the bulb being placed upon the sand which thus tends to keep the bottom fairly dry. This latter method is also useful in heavy soils. Well decayed manure is best for bulbs. Fresh manure is not safe. Leaf mold and sand are excellent where the soils are inclined to be heavy. Spading should be fully a foot deep for most bulbs, and for lilies 18 inches. Only the largest bulbs should be planted more than 4 inches deep; the smallest only 1 inch to 3 inches.

How long bulbs may remain in one place depends upon the kind. Lilies need not be disturbed for years; Narcissus or Daffodils may remain until they begin to fail; Tulips, Hyacinths and Crocus may stand 2 years. Tulips and Hyacinths do better if taken up every year. Bulbs to be dug up should be allowed to remain in the ground until the foliage has died or at least turned yellow so as to give the bulbs a chance to ripen fully. Some people dig the bulbs before this and cover them with soil in a sandy place. The practice is better than cutting off the foliage at once but should not be done if the bulbs can be left till full mature. When dug the bulbs should be spread out thinly in a cool, airy place until they have dried, when the trash may be cleaned off and the bulbs themselves stored until planting time. Bulbs dug prematurely should be planted where little will be expected of them.

Little bulbs that blossom very early—Crocus, Snowdrop, Scilla, Chionodoxa, and Grape hyacinth—are often planted among the grass in lawns. They look very pretty there, but generally they run out in 2 or 3 years even when the grass is not cut until after the tops have died down. Narcissus and Daffodil will do well among meadow grasses provided no cutting is done before the regular haying season.

Among the above are some that bloom well in the dwelling. The most satisfactory are Hyacinths, Crocus, and certain varieties of Tulip and Narcissus.

Tender bulbs. Nothing in the management of tender bulbs differs from that of

Principal Hardy Bulbs and Similar Plants for Fall Planting

Crocus	Narcissus	Chionodoxa
Hyacinth	Daffodil	Hardy alliums
Tulip	Jonquil	Camassia
Snowdrop	Snowflake	Lilies
Bulbocodium	Lily-of-the-valley	Winter aconite
Dog's-tooth violet	Crown Imperial	Fritillary
Trillium	Peony	Iris
Bleeding-heart	Tuberous anemones	Tuberous buttercups

hardy bulbs, except that they must not be planted before the ground becomes fairly warm in spring and that they must be dug in the fall before the ground freezes hard, and stored in a dry, preferably fairly mild room or cellar until thoroughly dry when they may be cleaned. For earliest blossoms some may be started in the house and transplanted to the garden after danger of frost has passed. At that time or even earlier—a week or two, perhaps—others of the same kinds may be planted out of doors. Perhaps a couple of weeks later another lot may be planted. Thus a long succession of bloom may be secured. The leading tender "bulbs" are Gladiolus, Tigridia, Tuberose, Montbretia, Dahlia, Canna, Arum, Calla, Amaryllis, Ismene, Calochortus, Bessera, Alstremeria, Tuberous begonia, Anomatheca, Bravoa, Zephyranthes, Madeira vine, Cinnamon vine, Cooperia, Galtonia (Hyacinthus candicans) Gloxinia, Tritoma, Oxalis, and Caladium.

HERBACEOUS PERENNIALS. There are plants which, like Rhubarb, Asparagus, Peony, and Bleeding heart, have roots which live for many years but tops that die at the close of the growing season. Among them are many of the most beautiful and satisfactory plants that can be grown both for flowers and for ornamental effects. While they may be allowed to remain in the same place for years there are few that are not better handled, either by successional plantings 2 to 5 years apart or by division of the clumps after 1 to 3 seasons of bloom. They seem to fill the ground with useless roots, become choked with quack grass or to use up the plant food in the soil; so, when they are seen to be failing, they may be allowed to grow until the close of the season and then dug up, divided and the young fresh and strong parts replanted, preferably in a new location. This is the easiest method of propagation at home. Cuttings of the roots and the stems are often used by florists and nurserymen, but where the gardener has not already plants to start with the best method is by means of seeds as follows:

Herbaceous perennials are mostly slower to grow than are annuals, but they are as easily grown from seed and where one wants a large number of plants in a given time and with little cost the method is highly satisfactory. Many kinds when sown in early spring will blossom later the first season than older plants; others can hardly be made to bloom before the second season. While florists use greenhouses and hotbeds for starting the plants, the home gardener may count on as great success and less bother from outdoor March, April, and May sowings if he will make his seedbed in a warm, sheltered, but not too sunny place. Preferably the surface of the bed should be raised 3 to 6 inches above the general level and the soil be made very fine before sowing the seed. It will be convenient to draw shallow drills 3 to 6 inches apart from front to back of the bed which should not be wider than 3 feet, preferably 30 inches.

Sow thinly, only one kind in a row. The time required for germination varies, and depends largely on the age of the seed and how it has been kept. New seed sown as soon as gathered grows quickly. Radish seeds may be dropped a couple of inches apart in the rows and as they will sprout in less than a week, they mark the positions of the rows. Cover the seeds thinly, press the soil down gently with a brick, water if necessary and after the wet look has disappeared, scatter fine soil thinly over the surface to help retain the moisture below. In sunny and windy weather shade the bed with fine boughs, papers or lath frames, but take them off toward evening. After the seedlings have developed their first true leaves, thin out the weak and unnecessary ones so as to give the stronger ones a better chance to develop well. The thinned out ones may be pinched out in other soil if desired. When the plants are 2 or 3 inches tall they may be planted where they are to flower.

Many successful growers sow seed fresh in July or August, and some in September or October as described above. For the hot weather sowings the beds should be placed in a shaded part of the garden but not beneath trees, otherwise they will become leggy or spindly and inferior. It is usually best to sow the seeds in shallow boxes one kind to a box, because each box may be handled separately, whereas if two or more kinds are in the one box there is more trouble in management since one may require different treatment from the other. The plants should at first be transplanted to other boxes and kept growing steadily until large enough to set out in the garden. Usually this is by the middle of September for the July and early August sowings. When no space can be arranged for them in the flower garden or the border, plant them in the vegetable garden for the winter and transplant them to permanent quarters in the spring. During the winter give them a light mulch of marsh hay or straw free from weed seeds. The fall sowings may be in cold frames and left there properly protected until spring. All these sowings should give plants that blossom the following summer.

Hardy Shrubs. Except in the cold North and in the high mountainous states, hardy

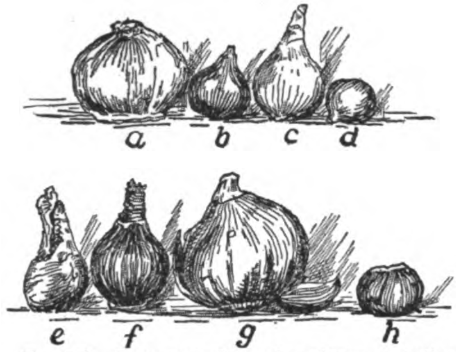


FIG. 512. Types and relative sizes of common bulbs: *a* Hyacinth, *b* Tulip, *c* Daffodil, *d* Sweet Jonquil, *e* Poet's narcissus, *f* Paper white narcissus, *g* Sacred lily, *h* Crocus. (The Garden Magazine.)

shrubs may be planted in the fall as soon as the leaves have dropped. Never should the leaves be pulled or cut off shrubs to be fall planted because winterkilling is almost sure to follow. Shrubs that do not ripen early enough to be fall planted at least 3 weeks before winter sets in should be planted in spring. A disadvantage of planting in spring is that the shrubs may have been dug in the fall and stored in the nurseryman's cellar. While such stock if properly stored is reliable, it often dries so seriously before it can be planted that it may either fail to grow or make such a poor growth that it will die the following winter.

Nursery-grown stock is almost sure to be better than shrubs of the same age grown in the fields and woods. Therefore, when wild shrubs are to be transplanted the younger and smaller specimens should be selected because they are more likely to grow. Again, nursery stock that has been transplanted or root pruned in the nursery is more likely to grow than untransplanted shrubs of the same age because the roots have been confined by these practices to small areas. This is especially true of shrubs that are difficult to transplant. The root pruning should always be done a year or two before the transplanting to the garden is to be done.

Before the planting is to be done the area to be planted should be plowed or spaded and enriched more or less. Always the earth should be trodden firmly around the newly planted shrubs and some loose earth scattered over the surface, which should be left level or slightly dished rather than crowning around the plants. During the first 2 or 3 years, annual and biennial plants, perhaps also perennials, may be planted among the shrubs to get rid of the bare effect. During this time also the surface may be kept hoed and raked to keep down weeds and maintain a loose surface.

Large shrubs such as Mockorange and Lilac may be planted never less than 4 to 6 feet apart, smaller ones 2 or 3 to obtain quick effects; but as soon as the bushes begin to crowd, half or more may be dug up and transplanted. Never should the plants be set in straight rows unless they are to stand against the borders of the area or of a walk or drive, always irregularly so as to get rid of stiffness. A deep mulch of leaves, leaf mold, or manure will greatly improve conditions of growth, so it should always be given when possible. After the third year, enough leaves should be caught by the shrubs themselves to serve this purpose.

At the time of planting and transplanting, the tops should be severely cut back—50 to 75 per cent—so as to balance the loss of roots. After that do no cutting except to restrain too rampant growth. To shear a shrub is almost always to rob it of its beauty. The great majority of flowering shrubs that bloom before midsummer develop their blossom buds the season before they flower. They must, therefore, not be pruned during the dormant season, except to remove dead, diseased, dying or undesirable parts, because such pruning robs the plant of its blossom buds and if severe may make many of those that remain fail to develop properly. Shrubs that blossom after midsummer may be pruned in the spring. When the Golden bell or the Lilac have dropped their flowers, do any pruning that may be necessary, but wait till spring to prune the Hydrangea and other late-bloomers because some parts may be killed by the winter.

Since late summer and autumn is the season when flowers are scarcest, special care should be taken to select shrubs that bloom then. The following are among the best: Clethra, Witch hazel, Caryopteris, Hydrangea, Baccharis, Cephalanthus, Rus cotinus, Hypericum, Lespedeza, Hibiscus, and Tamarisk. By choosing among these first and filling in with shrubs that bloom earlier in the season, one may have a garden that is different from the usual run. To add to the attraction of the garden during winter, shrubs that have odd-colored bark or fruits that hang on well may be chosen. Among these are: Berberis, Corylus, Crataegus, Colutea, Ilex, Evonymus, Ostrya, Physocarpus, Pyracantha, Ptelia, Rhodotypos, Pyrus, Staphylea, Symphoricarpus, Viburnum, Xanthoceras, Rosa, Cornus, Betula, and Salix.

CLIMBING AND TRAILING PLANTS. Nothing in the culture of vines differs from that of other plants except that supports are necessary. Most of the species require little space in which to grow because they reach above other nearby plants. According to their duration they may be grouped into annuals or biennials (such as Adlumia); herbaceous perennials (such as Madeira vine and Cinnamon vines); and as woody perennials such as Wistaria and Trumpet creeper. In the first group are both tender species

such as Nasturtium and Scarlet runner bean, and hardy ones such as Sweet pea. In growing vines it is necessary to know to which of these groups the plants belong, also the method whereby the plants climb. Some species such as Climbing roses merely sprawl over the ground or reach up on supports; others such as Bitter sweet (Celastrus) and Morning glory twine around the support. But those plants that belong to the third and largest group have special ways of clinging by tendrils as in the Grape and the Wild cucumber; by holdfast roots as in the Trumpet creeper and Boston ivy, and by leaf stalks as in Clematis.

Vines are most useful in hiding unsightly objects or parts of the ground, in relieving the stiffness of walls, fences and verandas and in covering bare spots. To make them grow unusually tall the ground should be made very rich, but in such case fewer flowers may be expected from plants grown more or less for bloom. Vines are more and more largely used nowadays for growing on pillars, tall tree stumps, and dead trees as well as on pergolas and arbors. For such purposes the hardy woody ones are best—Grapes, Dutchman's pipe, Wistaria, Actinidia, Akebia, Honeysuckle, Trumpet creeper, Clematis, and Climbing roses. Where a wall is to be covered a clinging vine should be chosen so no supports will be necessary. For such purposes the most popular are Boston Ivy, Virginia creeper, Trumpet creeper, Climbing hydrangea, Euonymus, English ivy (on north sides of buildings and walls), and climbing rubber plant (*Ficus repens*) in the Southern states.

Quick-growing annual climbers are used to cover unsightly objects especially during the first year or two on new property. Among the best are Wild cucumber, Coboea, Morning glory, Moonflower, Nasturtium, Pumpkin, Squash, Gourds of various kinds and Japanese variegated hop. For trailing over the ground the following are excellent: Periwinkle, Perennial pea, Moneywort, Ground ivy, Dewberry, Rosa wichuraiana, Hernaria, Hall's or Japanese honeysuckle, and Nasturtium. The woods and the fence rows often contain good climbers, notably wild grapes, Bitter sweet, Wild cucumber (an annual whose seedlings are easy to transplant while small), Virgin's bower, May-pop (a species of passion flower common from Baltimore southward), Virginia creeper, Trumpet creeper, Green brier, Euonymus, Hall's honeysuckle, Wistaria, Yellow jasmine (Gelsemium, in the South), Climbing asparagus (common in the South) and various Jessamines (Jasminum, in the South). Some of these are natives, others have come from foreign countries but have escaped from gardens to the wilds.

FIG. 513. A General Jacqueminot rose before pruning

FIG. 514. The same rose after pruning. Severe pruning stimulates flower production.

TREES FOR ORNAMENT. The best to plant for ornament are generally the ones native to the district because they are hardy and usually adjusted naturally to withstand their enemies. When any have lost the power to resist disease or insect attacks as the Chestnut in the Eastern states it should be avoided and other trees chosen instead. Trees give such a tone to property that every home place should have at least one—a good one always. Care must be exercised, however, to allow ample space for each specimen so neither the area planted nor the trees themselves will seem crowded. If trees are already growing on the ground, the best should be saved rather than cut them all down and a fresh start made with small ones. If the species are undesirable they may be removed from time to time after the newly planted ones have made a good start.

Trees for shade only should have abundant leaves and dense heads. Those grown for blossoms may have any kind of foliage but should be associated with other trees if their foliage is unattractive. Among the former are Maples, Oaks, Box elder (not very desirable because it takes possession of the land too much), Ailanthus or Tree of heaven (preferably the female tree because the male when in bloom has a very offensive odor), Birch, Beech, Ash, Maidenhair tree (Ginkgo), Hickory, Walnut, Ironwood, Aspen, Buttonwood, Sassafras, Willow, Cypress, and Elm. Among the flowering trees are the following: Buckeye, Horse chestnut, Catalpa, Red-bud or Judas tree, Yellow wood or Virgilea, Honey locust, Kentucky coffee tree, Tulip tree, Cucumber tree, White bay tree, Mulberry, Laburnum, Wild cherry, Plum and Crab, Locust, Mountain ash or rowan, American linden or Basswood, and the fruit trees such as peach, plum, apple, quince, pear, cherry, and apricot.

So far as soil preparation and planting are concerned the same remarks as given under shrubs will apply to tree planting. Fall planting is desirable for fully ripened and hardy species after the leaves have dropped and at least 3 weeks before winter sets in.

FIG. 515. Cuttings: *a* simple two-bud cutting; *b* heel cutting; *c* mallet cutting; *d* single eye cutting

Always choice should be given to young trees instead of older ones. The top should always be cut back very severely—$\frac{1}{2}$ to $\frac{3}{4}$—so as to balance the loss of roots. Except to shape the tree little or no other pruning will be needed the first year. From then forward the less pruning the better, except where limbs cross each other badly or grow too long. A rule to remember is that winter pruning tends to make greater growth of the branches, whereas pinching back the young shoots before midsummer tends to induce flowering and fruitfulness.

Every time a small branch is cut back the cut should be close to a bud, say a quarter of an inch. Every time one is cut off entirely the wound should be made as close as possible to the branch or the trunk from which it starts. This will hasten healing and prevent damage by decay. Whenever a stub is left there is danger of rotting, not only of the stub alone but of the interior of the trunk. This will mean loss of the tree sooner or later.

Window Gardening

Window gardening may be either outdoor or indoor, the former being summer, the latter winter, work. For both outdoor and indoor planting, the receptacles should be large and heavy—boxes for porches being of not less than 1-inch white pine as long as the window is wide, 10 to 12 inches wide and 6 or 8 inches deep. If built of lighter material, they will warp and split; if smaller inside, the soil will dry out too quickly. Zinc or galvanized trays or pans to go inside the boxes are good but not necessary. Holes in the bottom are necessary for drainage in any case.

The soil for all boxes, flower pots, etc., should be richer and more porous than ordinary garden soil. Sand, leaf mold, and well-decayed manure will produce this texture when added to the garden soil. Before placing it in the box an inch layer of hard coal clinkers, broken pottery, or gravel should be placed in the bottom, then a layer of old manure. After the plants have been planted the soil should not be higher than half an inch below the rim of the box. For outdoor planting many people set the plants directly in the soil; for indoor use they merely plunge them pot and all. The latter method permits replacing plants that fail with new ones. When plunged, better results usually follow when sand or sphagnum moss is used instead of soil as these hold water well.

Feeding. After the plants have grown large and have filled the soil with roots, surface dressings of fertilizers are a great help. Among the best are bone dust and well-decayed manure. Instead of these, manure water may be used, say once a week. This is made by soaking manure in a barrel of water and allowing the clear liquor to leak into a convenient receptacle. At the approach of winter the outdoor box may be taken into the house, or when spring arrives the indoor box may be taken out of doors. Usually, however, it is best to fill the boxes with fresh soil and new plants.

Materials. Among the best plants for boxes are the following:

Drooping plants to be placed around the box border: Kenilworth ivy, Tropaeolum, Coboeia, Verbena, Othonna, Petunia, Sweet alyssum, Vinca and Wandering Jew. *Erect plants* for the centres; Begonia, Heliotrope, Geranium, Fuchsia, small Palms and many others. *For shady places:* Tradescantia, Senecio, Vinca, Kenilworth ivy, Moneywort, Sedum, Lygodium or Climbing fern, Smilax, Asparagus plumosus and Asparagus Sprengeri. *For sunny places*: Nasturtium, Sweet alyssum, Verbena, Lobelia, Petunia, Passion flower, Ice plant, Heliotrope, Geranium, Phlox Drummondii and other sun-loving plants.

Indoor conditions. Indoors the best results are secured during late fall, winter and early spring in southern, eastern, or south-eastern windows. Western windows are not so good and northern poorest of all. Always the largest amount of light should be the aim in winter window gardening. Uniformity of temperature and moisture of the air are important helps. There should not be wide variations especially of temperature from day

to day and between day and night. Most plants that can be grown in the dwelling need a night temperature of 50 to 60 and a day heat of 60 to 75. Many of them do not suffer seriously if the temperature is 5 degrees lower than these but more than that is risky. On sunny days the day temperature may be 5 or even 10 degrees higher than in cloudy weather. In brick, stone, concrete, and tile houses these temperatures are easy to maintain; but in frame houses, especially if unsheltered from the wind, the temperature often falls seriously during the night.

Steam, hot water, and hot air tend to make the air of rooms too dry for plants. Where they are used, extra provision should be made to moisten the air. Pans kept full of water on radiators or below registers are excellent. The kitchen, if sunny, is an excellent place for plants because the air there is moist. Gas used for fuel and for lighting is hard on plants. Where used, the plants should be kept in a bow window conservatory closed off by glass doors from the other part of the room.

Watering, etc. Occasional bathing or syringing of the foliage is necessary to get rid of dust and to keep the plants healthy. A bath-tub is excellent if the pots are laid on their sides and care is taken to prevent the soil from being washed out. The flowers should not be wetted and when Rex begonias are wetted their leaves should be quickly dried or they will become unsightly. Watering must be thorough when done. A little "now and again" is worse than useless. Thoroughly soak the soil then let it get almost too dry before getting another wetting. When the plants are in pots, the pots will give a metallic ring when "flicked" with the finger. This sound is very different from the dull thud they give when the soil in them is moist.

Plants from the garden. Many people like to take up some plants from the garden in the fall to grow in the house. Best results will be secured if, two or three weeks before, the spade is thrust vertically full depth into the soil as far out from the stem as the leaves extend and on all sides, the plant being allowed to remain in place. This cuts the long roots and forces the development of new ones nearer to the plant. When the plant is finally dug it should be potted in rich, friable soil, have a third or more of its leaf area cut off and be set in a cool moist place—never in the sun—until 2 or 3 weeks afterward. During this time the foliage should be syringed daily and, if needed, the soil wetted. Water should be given sparingly or even not at all while plants are taking their "rest" after a flowering period. Amaryllis, Azalea, Palms, Camellias, Rex and Tuberous begonias are conspicuous examples. Water may be given again when the plants show new growths and be increased in amount as they increase in activity.

Hanging Baskets. The great trouble with hanging baskets is too rapid drying out of the soil. Moss placed in the basket before the soil is put in is a great help; so is very fibrous soil composed largely of decayed sods and leaf mold with old cow manure. The best thing, however, is a small flower pot, preferably a new one, with its drainage hole corked tight. This if placed in the centre of the basket and kept full of water will maintain just the degree of moisture desired since the water will slowly seep through the pot into the surrounding earth. Baskets hung in light places out of heavy drafts of dry air will give better results than when exposed to the full sun and in airy places. No matter how the basket is put up, the plants will benefit by being submerged in a tub of water, once a week or oftener if in very dry air. The same kinds of plants used in window boxes will do well in hanging baskets.

Bulbs for indoor flowering. No group of plants gives so much satisfaction for so little outlay and so little effort as will the bulbs. Among the most satisfactory are Hyacinth (Dutch and Roman), Crocus, Tulip, Daffodil, Jonquil, Narcissus, Oxalis, Freesia, Snowdrop, and Easter lily. The bulbs should be bought as early in the fall as possible and planted at once. If this potting may be done in October, better results will follow than if in November or later. The soil should be a rich sandy loam, either naturally or made so artificially. In the bottom of flower pots, preferably not smaller than 5 inches, place drainage of charcoal, broken crockery, clinkers or pebbles, then earth enough so the tips of the covered bulbs will be just below the rim of the pot and the soil half an inch below. Place the pots in a tub with a couple of inches of water until the surface shows wet, then let drain and finally store in a cellar, a closet or a cold frame—any dark, cool place where they may be easily reached 6 or 8 weeks later. Never should they be in a light place because every effort should be made to have a vigorous root system well developed before

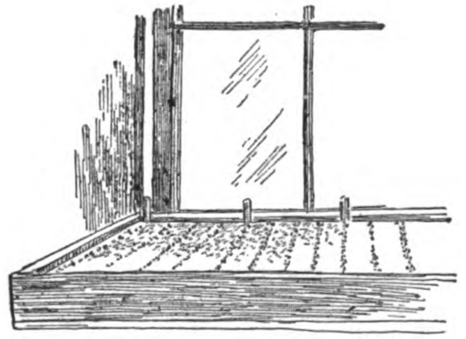


FIG. 516. Starting seeds in a flat set in a south window. Newspapers or some other protection should be spread over it during cold nights.

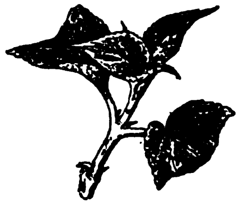


FIG. 517. A typical soft-wood cutting, by which many window and outdoor garden plants can be propagated.

the top starts at all. Unless this plan is followed, poor flowers will result.

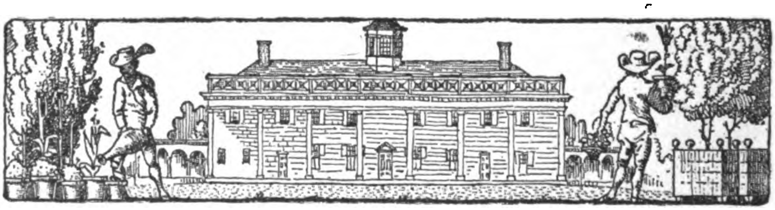
If stored out of doors, a mulch of litter will prevent deep freezing—but freezing the bulbs does not hurt any of the plants mentioned. When removed to the house, they should first be taken to a cool room to thaw out slowly. In 2 or 3 days to a week they may be moved to a warm, light room. From now forward they will need ample water. When the buds appear the pots may even stand in saucers full of water, especially if the air of the room is dry. Full sunlight when the blossoms begin to open will heighten the colors. To make the flowers last long, however, the plants should be moved to less sunny and less warm quarters after the blossoms have opened.

Hyacinth, Narcissus, Daffodil, Jonquil, and Tulip do best in a temperature of 55 to 60 degrees until the flowers open, then 50. Easter lily should not be kept lower than 60 at night when quick flowering is desired. Freesia does not need to be kept so long in the dark. It does well in a night temperature of 50 until the tops are formed when 50 to 60 is better. Crocus, Snowdrop, Scilla, Chionodoxa and other little bulbs started as above respond very quickly to heat. They need no forcing but will bloom at 45 degrees or even lower. When their tops begin to appear, they may be moved at once to the light.

Flowers of Different States and Provinces

(From Bailey's Standard Cyclopedia of Horticulture)

Alabama	Goldenrod	Missouri	Goldenrod
Alaska	Forget-me-not	Montana	Bitter-root (Lewisia)
Arkansas	Apple blossom	Nebraska	Goldenrod
California	Golden poppy	New Jersey	Violet
Canada	Sugar maple	New York	Rose
Colorado	Blue columbine	North Carolina	Daisy
Connecticut	Mountain laurel	North Dakota	Wild rose
Delaware	Peach	Nova Scotia	Arbutus
Florida	Orange blossoms	Ohio	Red carnation
Georgia	Cherokee rose	Oklahoma	Mistletoe
Idaho	Syringa	Oregon	Oregon grape (Mahonia)
Illinois	Native violet	Pennsylvania	Laurel
Indiana	Carnation (pink)	Rhode Island	Violet
Iowa	Goldenrod	South Dakota	Pasque flower (Anemone)
Kansas	Sunflower	Tennessee	Daisy
Kentucky	Goldenflower	Texas	Blue bonnet, lupines
Louisiana	Magnolia	Utah	Sego lily (Calochortus)
Maine	Pine cone and tassel	Vermont	Red clover
Maryland	Black-eyed Susan	Washington	Rhododendron
Massachusetts	Arbutus, May-flower	West Virginia	Rhododendron
Minnesota	Moccasin flower	Wisconsin	Violet
Mississippi	Magnolia	Wyoming	Gentian
Hawaii	Lehua (Metrosideros)		



FARM KNOWLEDGE

VOLUME II—PART V

Crop Improvement and Protection

CROPS may be improved in quantity and in quality. The factors upon which such improvement rests are (1) the soil in which the crop is grown and (2) the crop plants themselves. Previous chapters have discussed soils, their management, the principles underlying different systems of farming, and the generally approved methods of raising crops. There remain two lines of effort to which practical farmers can devote themselves in still further increasing and improving their crop yields. One of these consists of the production of heavier yielding sorts, of varieties better suited to particular conditions, of "making two better bushels grow where one grew before"; this is actually *crop improvement.* The second line of effort involves the protection of these increased crops from such dangers or enemies as might threaten their welfare. The practices that accomplish these two results efficiently and economically form the basis of successful and progressive farming.

Strictly speaking the production of new, improved varieties of plants is the task of scientists—professional plant breeders. Likewise, the study of injurious insects and plant diseases—of the damage they do and the methods by which they can be controlled—is the field of another group of scientists called *entomologists* and *plant pathologists.* Their problems and methods are not the problems and the methods of the farmer; but, at the same time, every farmer can develop his systems and improve his practices in accordance with what these scientists have taught us. In doing so, he too can play a part in the work of crop improvement—work that is profitable no less to himself than to the agriculture of the whole country.—EDITOR.

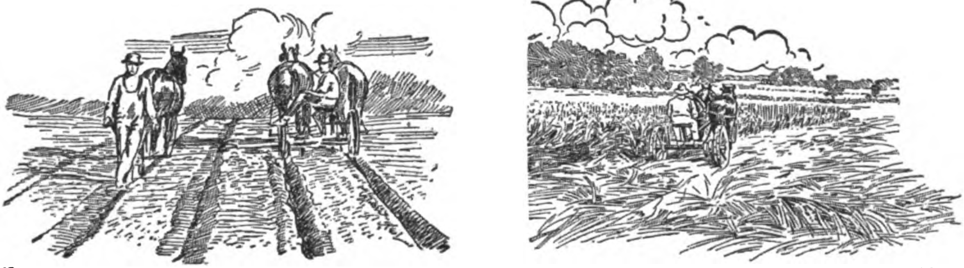


FIG. 518. "As ye sow, so shall ye reap," is true enough in farming as throughout life; but there are many things besides sowing that the farmer can do to insure, or at least make probable, a good crop

CHAPTER 31

Crop Improvement

By THOMAS P. COOPER, *Dean of the College of Agriculture and Director of the Experiment Station, University of Kentucky, whose work for a number of years has been on one phase or another of this subject. Soon after graduating from the University of Minnesota he became Assistant in Farm Management there. After serving as special agent for the Federal Bureau of Statistics for a short time, he had charge of the farm demonstration work in Minnesota from* 1908 *to* 1911, *doing the first work of this kind ever attempted in the northern states. For the next* 3 *years he was Director of the Better Farming Association of North Dakota which from the very first has lived up to the most and best that its name implies. From* 1914 *to* 1918 *he was Director of the Extension Department and Experiment Station of the N. D. Agricultural College in which capacity he carried his work still farther along, constantly widening the field of his efforts and the sphere of their effective influence.*—EDITOR.

CROP improvement is desirable because either the better quality brings higher prices, or the bigger yields increase the farm's income. Ordinarily improvement in quantity is brought about by better tillage (Chapter 4), increased fertility of the soil (Chapter 3), the use of better seed, or the use of superior-yielding strains or varieties. Quality is generally improved by selection or by breeding toward a higher ideal, or a combination of these.

Superior varieties or strains of crops may be produced for any and every condition of soil and climate with which the farmer comes in contact. It is naturally a slow process, but one that every farmer may take part in. A man need not be a Burbank to develop superior strains or to improve the crops grown on his farm; but he must have a defined understanding of his needs and keep working to that ideal.

Methods of improving plants have been developed to a high degree by the state agricultural experiment stations. Their work has frequently resulted in giving to the world new strains that yield from 15 to 50 per cent more than sorts previously or commonly grown. Similarly, improvements have been made in the quality of the product, giving rise to wheat with a higher or lower gluten content; corn with a greatly increased protein content; potato varieties of superior baking qualities, and so on. If by changing the variety of a grain or by improving it in some respect one may, under exactly the same cultural soil, or climatic conditions, increase returns 10 per cent or more, are not the time and study and effort given to the work worth while? Under normal conditions, increasing the number of grains in the head by 3 or 4 will increase the yield of a small grain

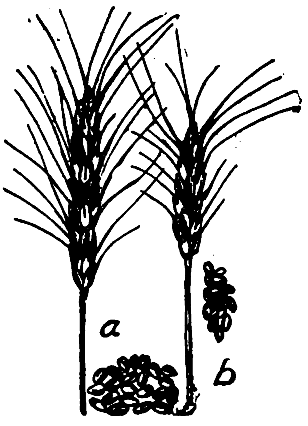


FIG. 519. Good and poor wheat heads and the seed contained by similar heads. Which would *you* plant?

FIG. 520. Single oat plants showing the type to grow and the type to breed away from.

crop from 10 to 20 per cent; deepening the kernels of corn or carrying them well over toward the butt may easily make a difference in yield of 5 bushels per acre. Other illustrative possibilities are: Potatoes grown smoother or with shallow eyes, or strains of superior productivity; cotton with a longer fiber; tobacco with a better leaf; grass crops of greater leafiness or vigor, able to produce the best pastures or meadows; hemp improved by increasing the length of the stalk between the nodes, etc. These and similar problems represent opportunities for improvement in crops as a whole and are almost invariably possible on any individual farm.

FIG. 521. Selection in the field insures the choice of the best seed from the best plants—those that yield best under local conditions.

In every community there is need of a farmer who will use care and foresight in the production of improved varieties or strains of crops commonly grown in that neighborhood. It is not an opportunity that should be slighted, either, for the work is both remunerative and pleasant. Many of our present superior varieties bear the names of farmers through whose efforts they were developed, and who in most cases have reaped a generous harvest therefrom.

Variations in soil or climate offer abundant opportunity for individual effort in improving a crop so that it may be especially adapted to special conditions. For instance, the northern states, with their high altitudes, and often early frosts, require varieties of corn that will mature from year to year and at the same time produce good yields of high quality. This problem is an ever-present one varying often from township to township. As an illustration, a careful corn grower in North Dakota who gave special attention to a corn adapted to short seasons brought out a strain of Minnesota No. 13 that gives markedly superior yields over almost one fifth of the state.

The farmer's part in plant improvement. Whether or not he can take part in this larger work, every farmer should, in a small way at least, provide for the improvement of crops grown on his own farm. It is possible that actual improvement in yield or quality may not be obtained. Nevertheless, efforts should be made to select for improvement, otherwise uniformity and high standards of product cannot be maintained. The breeder of live stock well understands the importance of bringing about improvement in his herd or flock each year. The producer of farm crops can advantageously use the same care to bring about uniformity and improvement. In plants as in animals there is no such thing as standing still—a strain must keep getting better or it at once begins to get worse.

As illustrating the rich field of opportunity that lies open to the progressive farmer a few of the actual achievements of the past may be cited. They are typical of some of the striking occurrences among the most widely grown crops, and suggest further lines of progress for the individual farmer to take up.

Corn. Farmers throughout the corn belt may work only for improvement of yields in their corn. Farmers in the North have problems of early maturity, soil adaptation, height of ear, and leafiness of the stalk that need to be solved in each community. In the semi-arid regions a corn must be developed that will withstand to a great degree drought and hot winds. Possibly a deeper-rooting corn plant is required. Every farmer in the arid

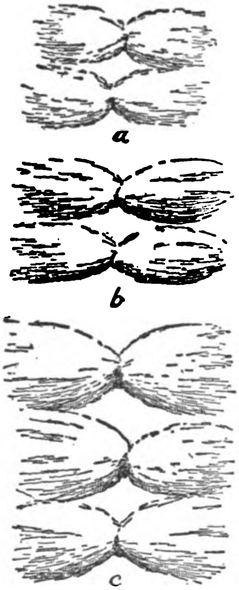


FIG. 522. Three generations of Egyptian cotton showing the result of selection. Both length and amount of fiber were greatly increased.

region has had the experience of finding in his field occasional corn plants that seem to withstand a period of drought or hot wind better than those around them. Often such plants offer real opportunities for selection and propagation.

Cotton. The cotton farmer may advantageously increase the length of the cotton fiber. In recent years, it is estimated, the development of the automobile industry alone has increased the demand for the longer staple cottons used in the tire fabrics 300 per cent. Growers of Sea Island cotton are accustomed to narrow selections down to one superior plant. The seed is multiplied from this plant for 2 or 3 years, then used in the general planting. The result is that Sea Island cotton is very uniform and of exceedingly high quality. Similarly, the grower of upland cotton may select his best plant or plants and grow small crops from their seed until he has enough for use in field sowing. Cotton is cross fertilized (p. 434) so that there is necessity of maintaining seed plants from year to year. In this manner, the production of desirable and uniform cotton may be maintained and the length of the staple increased.

Wheat has been grown, and is under cultivation, to a greater or less extent, in every section of the United States suited climatically to its production. Any farmer, by selecting seed from the plants which exhibit desired qualities to the greatest degree, may materially improve the crop. Qualities such as yield, winter hardiness, rust resistance, earliness in ripening, strength of stalk, drought resistance, or non-shattering are all subject to improvement, and may advantageously be intensified.

The U. S. Department of Agriculture outlined a few years ago some of the special needs of improvement in wheat in the different wheat-growing districts. Some of the problems, as they appeared in the hard-spring, hard-winter, and durum-wheat districts were as follows:

Hard-spring-wheat district:

(a) Present average yield per acre, about 13 bushels.
(b) Chief varieties at present grown: Saskatchewan Fife, Scotch Fife, Powers Fife, Wellman's Fife, Haynes Bluestem, Bolton's Bluestem.
(c) Needs of the grower: Early maturity; rust resistance; drought resistance; hardy winter varieties.

Hard-winter-wheat district:

(a) Present average yield per acre, about 12¾ bushels.
(b) Chief varieties at present grown: Turkey, Fulcaster, Fultz, May, Zimmerman.
(c) Needs of the grower: Drought resistance; hardy winter varieties; early maturity.

Durum-wheat district:

(a) Present average yield per acre, 11¼ bushels.
(b) Chief varieties at present grown: Mediterranean, Fulcaster, Nicaragua, Turkey.
(c) Needs of the grower: Macaroni varieties; drought resistance; rust resistance; early maturity.

Examples of the characteristics of special importance in breeding the common bread-wheat group and the durum group are cited from the same authority:

Common Bread-Wheat group: (a) Excellence of gluten content for bread making. (b) Excellence of certain varieties for cracker making. (c) Yielding power of certain sorts. (d) Rust resistance (in some varieties). (e) Winter hardiness of certain varieties. (f) Resistance to drought of certain varieties. (g) Early maturity (in some varieties).

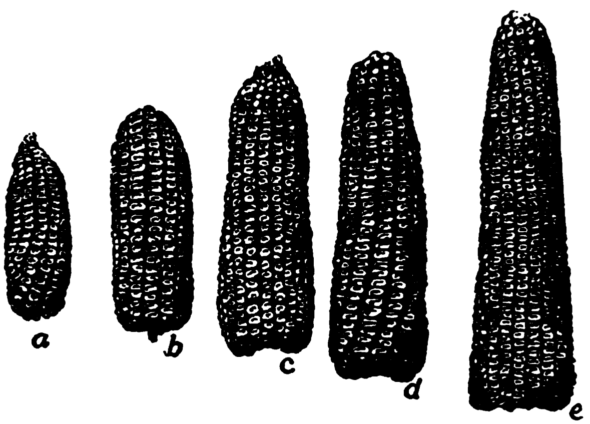


FIG. 523. How corn ears vary. The yields possible from an acre (8,000 stalks) bearing each of these types are *a* 20 bushels; *b* 40; *c* 62; *d* 80; and *e* 108. Careful selection has a cash value. (Va. Bulletin 165.

Durum group: (a) Excellence of gluten content for making macaroni and other pastes. (b) Resistance to drought. (c) Resistance to orange-leaf rust.

A number of wheat varieties grown in the spring- and winter-wheat states have been produced through selection by farmers. The Wellman Fife is a good example. In 1878, D. L. Wellman of Frazee, Minnesota, received a sample of Scotch Fife wheat from Saskatchewan. This seed was sown the spring of the following year, but it was found that the seed was badly mixed. Mr. Wellman removed all of the plants except those of the true Fife and propagated those from year to year. In this manner he gradually bred up a pure strain of Fife which became known as the Saskatchewan Fife. Later some of the wheat with unusually large heads was selected and this became a distinct sort, known as Wellman's Fife. In a similar manner, Powers Fife, Haynes Bluestem, and Bolton's Bluestem were produced.

Alfalfa. To the ordinary grower individual alfalfa plants seem to differ but little. Attention in many instances has not been given to strains. In sections of the central Northwest, alfalfa must possess superior hardiness if it is to survive the long cold winters. One of the most prominent varieties is Grimm because of its value in these northern states. This alfalfa was originally introduced in Carver County, Minnesota, by an early German settler. It has proven its value through ability to withstand severe winter conditions, growers of this sort always retaining their stands even under severe conditions while growers of common varieties often lose their plantings through freezing out. This is an excellent example of the development of special hardy strains fitted to a peculiar condition of climate.

Apple. The Wealthy apple was originated by Peter M. Gideon of Minnesota, having been obtained as a result of selection. Many apple seeds were planted and the development of the seedling trees watched. One plant

FIG. 524. A cotton plant affected with wilt (*right*), and a resistant one (*left*) such as plant breeders use in developing resistant strains of great value.

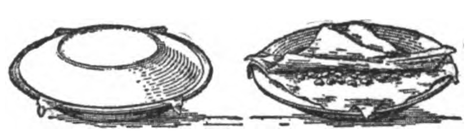


FIG. 525. A very simple apparatus suitable for testing a small amount of seed. Keep the cloth (or blotting paper if preferred) moist.

withstood the severe Minnesota winters, and at the same time produced fruit of good quality. This was the beginning of the Wealthy apple. Scions from this tree were grafted on other trees and grafts were made on seedling roots, to make independent trees. Thus, this apple became distributed and of great value to the producers of the Northwest. It was the first prominent result of the efforts to produce a hardy apple for the Northwest.

Sugar beet. The Vilmorins, prominent French seedsmen, some years ago, gave their attention to the problem of producing sugar beets containing a larger percentage of sugar than the common sorts. Through selection and breeding, they increased the percentage of sugar in the juice of the roots of the beet plant by almost 100 per cent. Thus was made possible a great industry which has been profitable to both farmers and manufacturers, and has given the whole world cheaper sugar.

Plant Improvement by Experiment Stations

Many of the men engaged in the agricultural experiment stations have carried on splendid work in breeding and plant development. Among the pioneer workers was Professor Willet M. Hays, connected with the Agricultural Experiment Station of the University of Minnesota and later Assistant-Secretary of Agriculture. Soon after the establishment of this station he began the study of the possibilities of plant improvement through selection and breeding. One of the early products resulting from his studies was a bluestem wheat known as No. 169. The manner of its development is interesting as it illustrates the methods used in a general way by many plant breeders in bringing about an improvement of small grains, and also represents one of the earlier lines of plant improvement attempted by an experiment station.

Several of the best single plants were chosen from 400 plants of bluestem. Each of the selected plants had produced a high yield, and the grain obtained from it was sown separately for a few years and kept pure, until enough seed was obtained to seed a small plot. These plots were then compared with each other and with the parent strain as to yield, vigor and freedom from disease. A few of the new strains that had thus been produced through selection proved superior to any of

the others and were also superior to the parent strain. Out of all the selections the individual plant, later known as No. 169, stood out as individually superior, and all others were discarded. Extensive trials were made in coöperation with farmers under field conditions as to the yielding power of this variety. Under ordinary field conditions in a large part of Minnesota it yielded from 1 to 2 bushels per acre more than the varieties commonly found on farms within the state. Ultimately this variety became the dominant bluestem of the Northwest. Many similar examples might be cited, for there are few experiment stations that have not developed strains or varieties of farm plants that have proven superior to the varieties in general use.

Plant introductions. The United States Department of Agriculture and the various state experiment stations are doing a great deal to aid the farmer in improving his crops by locating foreign plants which, when transplanted in the United States, have proven of superior value. The Department of Agriculture established durum wheat in the United States as a result of selections of wheats made in Russia. New varieties of alfalfa have been brought into the country through departmental and state activities; and many other examples might be mentioned.

The farmer may participate in and benefit from this work by keeping in close touch with his state experiment station and the Department of Agriculture trial farms at Chico, California; Miami and Brooksville, Florida; Rockville, Maryland; and Bellingham, Washington.

Frequently, the National Department and the experiment stations desire to test out under farm conditions the possibilities of certain plants and of seeds. To do this, they must secure the coöperation of farmers in every section of the states concerned. The seeds or plants are furnished by the station, the farmer grows and cultivates them according to instructions and later reports as to their results. Frequently, in this manner, a farmer may come into possession, at a comparatively early date, of seeds that are of exceeding value. The work of such coöperating farmers through the United States is of benefit not only to themselves but to all the farmers of the Nation.

Practical Plant Improvement

The breeding of plants or their selection for purposes of improvement is relatively a simple problem. After one has once fixed in mind the ideal toward which he desires to work, the task of reaching that ideal is largely a matter of time, patience, and discrimination. Two methods may be used in developing a new type-strain or variety: (1) by means of crossing or *hybridization*; (2) by means of selection.

CROSSING. The crossing or hybridization of plants to produce new qualities is more or less technical and involves a knowledge of the botany of the flower and sufficient technique to artificially fertilize the flower at the proper time. It is mainly for the purpose of introducing a larger variation in the resulting plants than may be obtained through selection. Technically, crossing means the union of 2 varieties, while hybridizing means the crossing of 2 species; but often the words—hybridization and crossing are used interchangeably.

The Reproductive Organs. The flower is the reproductive organ of the plant. It consists essentially of (1) the protective covering, and (2) the stamens and pistil which are the essential parts in the production of seed. The stamen consists of a slender stem with a larger upper portion called the *anther* which contains the pollen. The pistil is made up of (1) the *ovary* in which later on the seeds develop; (2) the *stigma*, the upper portion connecting with the ovary by (3) a narrow elongated portion called the *style*. Fertilization takes place when a grain of pollen is transferred to the stigma, where it sends out a tube that grows down through the style to the ovary and fertilizes the young seed (*ovum*).

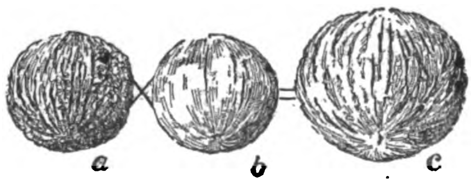


FIG. 526. Successful crossing. A black walnut tree bearing nuts like *a* was crossed with another yielding nuts like *b*; the resulting hybrid bore better nuts like *c*.

Flowers are fertilized in 2 ways. In the one instance (as in corn, apple, etc.) the pistil is fertilized by the pollen from another plant; plants of this kind are cross-pollinated or open-fertilized. In the other (illustrated by wheat, oats, and many of the grasses) the pollen of a flower fertilizes the pistil in that same flower; such plants are close- or self-fertilized.

The crossing of close-fertilized plants. When self-pollinated plants are to be crossed, much care must be exercised in securing su-

perior plants. The spike or head is then prepared by removing all of the weaker florets, leaving only the stronger ones in the centre of the head. The anthers are then removed from the florets by means of small forceps or tweezers, and the head is covered with light tissue paper to prevent the introduction of foreign pollen. Within a few days the pistils are fully developed and ready for fertilization. The pollen of the neighboring plant with which the cross is desired in the anther sac is then brought and inserted into the floret in contact with the pistil, after which the spike is again covered to keep out foreign pollen. The resulting grains obtained from this cross are planted from year to year. Plants of the resulting generation that do not conform to the type in mind are discarded and careful selection in this way is continued until the type that the breeder has in mind, or something very like it or better, is obtained.

Crossing open-fertilized plants. The process of crossing the open-fertilized plants, such as corn, is much simpler than in the case of close-fertilized grains. Two plans are in general use. In the first, alternate rows of varieties may be planted and one row detasseled in order to insure its pollinization by the adjoining rows. The resulting seeds are then planted for 2 or 3 years and the superior plants selected from these plantings. The second plan involves the mixing in bulk of choice seeds of 2 varieties and their planting at the same time so that mixing may occur naturally. Poor plants in this nursery may be detasseled so that the resulting crosses will involve only vigorous, strong plants. Selections are then made from successive plantings of the seed thus obtained.

IMPROVEMENT BY SELECTION. The form of crop improvement most generally followed by farmers, and the simplest, is by selection alone. This is applicable to all varieties of grains and to all other farm crops. It requires a close consideration of differentiations between plants and a knowledge of the qualities that are desirable.

FIG. 527. In five years of corn breeding, the average height at which the ear is borne was increased by nearly three feet as shown by the line across the picture. This only suggests what science and man can accomplish.

At the experiment stations, plant breeders have grown large numbers of plants and from them secured individuals from which to make further selections. The farmer may make his selections direct from his fields. The selections obtained which seem to have merit should be sown from year to year, and plants of unlike characteristics eliminated until the resulting stock shows purity of strain and value. This may frequently require 4 to 10 years of careful effort.

The fixing of type. Fixing of type may be relatively difficult in crosses. It is accomplished through the growing of the progeny of the mother plants from year to year with a careful elimination of those plants that do not adhere to the type selected, until finally sufficient seed is obtained to reproduce, in field trials, plants that are all examples of the type determined upon. There is not the same difficulty in fixing type when selections are made. The law of breeding that "like produces like" enables the plant breeder to feel certain of the reproduction of the characteristics of his selection from year to year, unless he permits natural or artificial cross pollinization to take place.

Simple Methods of Improvement

Improvement may be brought about by grain farmers through the careful use of the fanning mill and seed plot; by the corn farmer through the ear to row method of testing his corn; by the cotton grower through seed plot or selections of superior plants from the cotton fields; and even by the vegetable gardener through making careful selections from superior varieties produced in his own garden. Too much stress cannot be placed upon the importance of maintaining or grading crops grown by some one of the methods suggested or others which may be followed equally well. The corn-growing or potato-growing farmer must rely to a great extent for improvement and uniformity upon the seed plot in which his superior plants are produced. Fruits may be improved by the grafting of improved varieties upon existing hardy root stocks.

The Seed Plot. Most farm crops may profitably be improved in a small way by the use of a seed plot which is merely a small area of ground, say an acre in extent, that may be properly prepared and sown to choice, selected seed. Plants grown on this acre may be kept pure by roguing (picking out the poorest—those that are "off type") if necessary, or by isolating the good ones in the event that they are open-fertilized. The seed plot is kept free from noxious weeds and the crop threshed separately. The seed thus obtained

FIG. 528. "A good fanning mill is probably the grain farmer's greatest asset"

is carefully tested to insure high germination and is used either for field seeding or for sowing on an increase plot which will later produce the seed required on the farm. Crops such as wheat, oats, barley, corn, potatoes, the various garden crops, etc., may be thus grown.

Minor methods for farm use. All farmers know that there are a few simple features in crop production which will enable them to improve their crops or maintain uniform standards. The prevention of undesirable crossing in corn is as important as prevention of an undesirable cross in livestock. The mixing of seed of unknown varieties is a bad practice; the resulting mixtures may bring lower grades and prices. The Federal grain standards for wheat announced in 1917 discriminate against mixtures by lowering grades. Seed fields should be so grown that they will not be subjected to cross-pollinization of poor varieties. All these methods might well be grouped under the general advice "Know and care for your plants."

New plants, strains, or varieties are put out from time to time by the agricultural experiment stations. These plants have been carefully developed and generally prove valuable. Every farmer should keep closely in touch with varieties as they are developed in his state, and prepare to test them out under field conditions in comparison with his own crops. If after several trials they prove superior to the varieties grown, the old ones should be discarded.

FIG. 529. A cheap magnifier for studying seed quality.

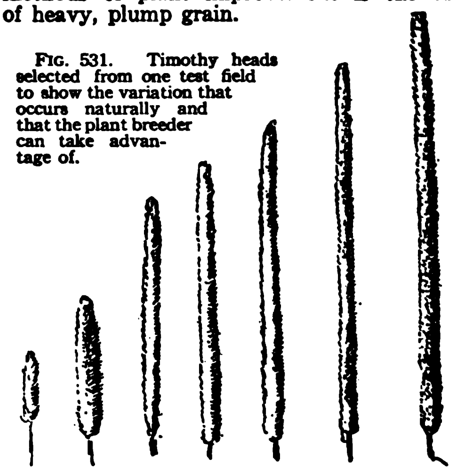
Leading seedsmen from time to time put out varieties that may well be compared with the crops grown upon the farm. As a rule, however, the farmer may depend upon his state experiment station for improved varieties. Few commercial organizations now attempt the development of new varieties or strains, but they act to the greatest extent as distributing agencies, leaving development work to the public institutions or to the few individuals endowed with the patience, enthusiasm, and genius to perform this important work.

Fairs, institutes, and crop shows of various kinds offer splendid opportunities to study and compare types, strains, or varieties that are coming into prominence. Farmers should use care in discarding crop varieties generally grown in their neighborhood. Also they should introduce new varieties only after ample trials show their superiority. When new strains are introduced care should be used to maintain purity—otherwise apparent deterioration may be rapid.

Selection by fanning mill. A good fanning mill is probably the grain farmer's greatest asset in maintaining uniformity of crops. Few grain-growing farmers will attempt to select in the field the vigorous strong plants from which to obtain their seed. The fanning mill will select with comparatively little labor the heaviest and plumpest grain in the crop. Some successful farmers make a practice of running their grain crop through the fanning mill and selecting by grading for weight the best 5 or 10 per cent of the total crop for seed. Experimental evidence as to the value of the heavy, plump seed in comparison with the lighter seed is somewhat conflicting. Successful farm practice, however, is unanimous in the opinion that one of the methods of plant improvement is the use of heavy, plump grain.

FIG. 530. A farm test plot for crop improvement

FIG. 531. Timothy heads selected from one test field to show the variation that occurs naturally and that the plant breeder can take advantage of.



Improvement by Crop Rotation

The development of a commercialized agriculture in the United States involved the production by farmers of crops that they could dispose of easily and advantageously. Each section of the United States as it has been settled has at first devoted itself largely to the production of a single crop that was found well adapted to the soil and climatic conditions. The lack of adequate markets for certain crops and the difficulty of transporting other crops intensified the production of the one crop which the farmer found could be most easily disposed of.

FIG. 532. Harvesting pure strains of test wheat, plot by plot in plant improvement work

Single cropping as a cause of failure. Thus pioneer farmers of the central states first raised wheat on the newly cleared lands. Wheat production continued until the accumulation of disease, insect pests, or other factors proved it to be an unreliable and unprofitable crop. Later the farmers turned their attention almost exclusively to the production of the corn crop, until it too began to fail. Similarly the farmers of the Northwest produced wheat exclusively; and the farmer of the South produced cotton exclusively. In each instance farmers in the area or section devoted to the production of a single crop sooner or later found themselves in economic difficulties. Crops failed from time to time and the farmers lost labor, seed, and return upon their capital investment.

Its effect on soils. Soils devoted chiefly to the production of any one crop, or of crops similar in character sooner or later fail to respond. The farmer finds changes taking place in them. Soils that were formerly friable and easily tilled become lumpy and bake easily; more labor is required to put the soil in condition for seeding; light soils begin to blow; crop yields decrease. The difficulties of securing sufficient labor and properly marketing the single crop that is produced, all tend to intensify as the country becomes older, and greater attention is given to the single crop specialty. Occasionally years in which climatic conditions are not favorable cause loss throughout entire, extensive districts, from which the farmers recover slowly. This is typical of the country growing a single crop and looking to that one crop for its total income.

The remedy. The most important step in remedying this condition of affairs is diversification, or the production of several money- or income-producing crops. Diversification of an industry such as agriculture naturally involves a rotation of crops. Any attempt to diversify the source of income by the production of certain crops continuously upon the same land, sooner or later results in a more complicated condition than did the production of a single crop, that is the problem is a more complex one, more factors must be taken into account. Consequently, the remedying of the ills of the single-crop system through diversification involves increased knowledge and skill that will insure a proper rotation of crops that will in turn permit of a permanent agriculture.

FIG. 533. Bundles of timothy showing yields from equal length rows of different inbred types. (N. Y. [Cornell] Bulletin 313.)

Crop rotation has for its object an increase in the yield per acre without a corresponding increase in the cost of production. According to one author "A rotation of crops is a recurring succession of plants covering a regular

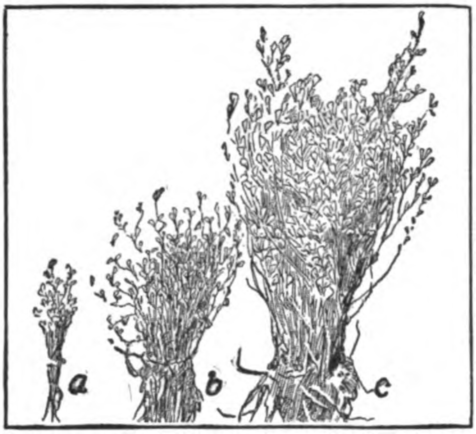


FIG. 534. Even good crops do well only if given good treatment. Each of these bundles contains twenty sweet clover plants. *a* Not treated; *b* inoculated; *c* seed inoculated and the soil limed.

period of years and maintained in alternating fields on the farm." From a farm standpoint a rotation is a succession of dissimilar crops grown upon the same land. Perhaps the best definition of rotation is an illustration: A grain crop such as wheat, oats, flax, or barley is grown on one field of the farm. A cultivated crop such as potatoes, corn, mangels or beets is grown on a second field. On a third field timothy and clover are grown. The next year the grain crops occupy the field which grew cultivated crops, the cultivated crops are grown in the grass field, and grass is grown on the field that produced grain. Such a regular sequence of a cultivated crop, a grass crop, and a grain crop is called a rotation; but unless the arrangement and plan of sequence is definite, the term cannot be rightly used. The production of wheat, oats, and flax year after year is not a rotation because of the similarity of the crops and of their effect upon the soil. This is merely an alternate cropping system.

Advantages of rotation. A rotation (1) supplies and conserves organic matter; (2) maintains or improves the physical condition of the soil; (3) increases crop yields; (4) stabilizes the farm income; (5) conserves moisture; (6) aids in the eradication of weeds and the destruction of insects and disease; and (7) distributes farm labor. Some of these benefits being especially related to other subjects such as soil management, etc., are merely mentioned here, being treated in greater detail elsewhere.

Rotation and plant food. A consideration of the advantages of crop rotation involves a knowledge of how plants feed. (See Vol. IV, Chapter 17.) This tells us in effect that there are 2 sources of plant food in the soil: (1) the available plant food, which is in a sufficiently soluble form to be taken up by the plant roots, but which is available at any one time in comparatively small quantities; (2) the unavailable food which embraces the larger supply, and which may be made available to plants by certain agricultural practices. The successful farmer so tills his soil and practises such methods as will make constantly available the necessary supply of the essential plant-food elements for plant production. One of the most important agencies in making available the insoluble plant foods in the soil is the action of decaying organic matter. Throughout the great agricultural regions of the United States, methods of agriculture must be adopted that will maintain or increase the stores of organic matter in the soil. The presence in considerable quantities and the decay of organic matter is responsible to a large degree for the great productivity of virgin soils.

Organic matter is rapidly removed from the soil by exhaustive cropping or by single cropping systems which do not provide for the addition of adequate quantities of organic matter from time to time. Even a very simple form of alternate cropping tends to conserve organic matter. For example, a system of farming which provides for the production of corn one year and that of grain the following year is generally profitable for a longer period than one that provides for the production of either one of the crops continually.

If a clover crop is introduced, a supply of organic matter is maintained for a still longer period. This has been very definitely determined by a series of experiments in crop rotations that have been made at a number of experiment stations throughout the country, the results of which have been repeated time and again on individual farms. There is no doubt that the most important cause of the increased yield in such cases is the fact that the supply of organic matter was increased and therefore the supply of available plant food more nearly maintained in the rotated and manured plots. One should not conclude from this that crop rotation in itself is sufficient to maintain fertility; it will not. It is, however, one of the first essentials.

Rotation and the soil's physical condition. The growing of grass and legume crops tends to maintain the physical condition of the soil, since organic matter is important not only from the standpoint of increasing fertility, but also in maintaining this physical condition. Virgin prairie soils are filled with roots and generally contain a large quantity of organic matter. It is a well-known fact that such

FIG. 535. Yields from alfalfa plots: *a* untreated; *b* limed; *c* inoculated; *d* limed and inoculated

soils work harder after the organic matter is exhausted.

Rotation and increased crop yields. Since crop rotation is an important factor in maintaining fertility, it necessarily follows that it must also increase crop yields. Aside from the effect of additions of organic matter, certain crops help to prepare the ground for other crops. A corn or potato crop, for example, is an excellent preparation for a wheat crop. Experiments at the North Dakota Experiment Station show that practically as much wheat will be produced by growing a crop of corn 1 year and wheat 2 years as may be obtained by growing wheat continually for the 3-year period. On the other hand, alfalfa or clover opens up the soil, adds vegetable matter, and is an excellent preparation for the corn or a potato crop. Grass crops in many sections of the United States are surest when sown in a grain that follows a cultivated crop. If the crops that are produced are largely fed to livestock and the manure returned to the soil, crop yields will be further increased. Thus each crop grown, with the exception of some of the grain crops that may be sold for cash, increases the available supply of plant food. The use of a crop rotation indirectly brings about a greater use of farm manures and thus increases to a still greater degree the crop yields that may be expected. In the writer's experience with large numbers of private farms, it has been shown that a good crop rotation may be expected to increase crop yields from 25 to 75 per cent more than those obtained under a continuous or alternate cropping system.

Rotation and the farm income. A rotation of crops with the diversification that it implies assists in stabilizing the farm income. When farmers rely upon the production of a single crop, unfavorable climatic conditions may cause a loss of the entire season's work. In a rotation that provides for at least 3 classes of crops, one or more will generally yield a fair return even under conditions that bring an absolute failure of the more important crops. Wheat in the North may fail, because of rust or climatic conditions; at the same time these conditions may be very favorable for the production of corn, potatoes, or grass crops. The boll-weevil may attack cotton and cause a total loss of the crop while oats, cowpeas, corn, and similar crops are unaffected. Similarly, certain climatic conditions may prove unfavorable for the corn or hay crop, but excellent for wheat. Farmers may not obtain as large an income under crop rotation in an exceedingly good year as might have been obtained by a single cropping system. But most years, and certainly on an average for a number of years, they will obtain a greater income by following a system of rotation.

Rotation and farm labor. Proper systems of crop rotation aid in the distribution of farm labor and its employment during the

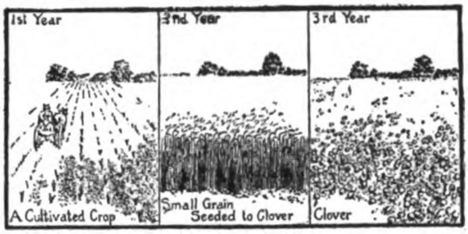


FIG. 536. A good all-round three-course rotation. (Wis. Bulletin 222)

growing season of the year. When a single crop or crops of a single class are produced there is a tendency to employ labor only at certain periods of the growing season. The wheat crop requires a large amount of labor mainly at seeding and at harvest time; the cotton crop uses a large amount of labor at picking time and but little labor during the other seasons; the hay crop, too, demands labor during a certain few periods. When the farm is devoted exclusively to any one of these classes of crops, the labor problem becomes acute in the planting and harvest season. When several classes of crops are produced, labor may be utilized throughout the season. Thus the planting of the corn crop requires labor immediately following the planting of spring grains; haying requires labor when it is not required for the grain crops; corn or potatoes need cultivation when men engaged in the production of grain would otherwise have little to do. Finally, a crop rotation usually calls for the maintenance of additional livestock. Labor on such a farm is needed more or less evenly throughout the year, as the greatest labor demand of livestock comes during the season that crops are not produced. Systems of farming that thus provide for the distribution of labor and its employment for the year are likely to prove most profitable and most stable.

Crop rotations often save labor. The growing of one crop often enables the land to be prepared with less labor for the succeeding crop. Wheat may be sown directly upon disked corn stubble, the land being plowed but once for the production of the 2 crops. A grass crop may be sown with the grain crops, in which case one plowing may easily provide for the growing of 3 crops: corn, wheat, and the grass which follows. Carefully collected data indicate that farms practising crop rotation require less labor per acre as a rule than do the farms that are not under proper systems of rotation.

The essentials of a good rotation. The essential features of a good rotation are: (1) an intertilled or cultivated crop; (2) a legume or grass crop and (3) a grain crop. From another standpoint a good rotation should include (1) an intertilled crop that will aid in the destruction of weeds and in maintaining the soil in a good condition of tilth; (2) a crop

which will bring direct cash returns; (3) a crop for the feeding of livestock; and (4) a crop which will increase the supply of vegetable matter and put nitrogen into the soil.

In the laying out of a rotation one should first determine the crops to be grown and the acreage that must be devoted to growing the money crops. The proportion of land in such crops and in those that return indirect profits will vary. Under most conditions it is good practice to plant approximately one half of the acreage to crops that will produce an indirect return, but which will also benefit the soil and indirectly bring about greater cash returns from the money crops. For example, a grass and clover crop or a corn crop may bring returns only through the sale of livestock and livestock products produced from feeding them. At the same time they may increase the direct returns from the grain crop by maintaining the soil in such condition that yields will be increased.

A good rotation or cropping system should provide a number of things: (1) It should furnish an abundance of roughage and feed for livestock. (2) The fields included in the rotation should be of approximately the same size and their arrangement should be such that they may be reached easily from the farmstead. (3) The area devoted to the production of each crop should be approximately the same from year to year. (4) The rotation should include grass and legume crops, which will aid in the maintenance of organic matter of the soil and add nitrogen. (5) Intertilled crops should be included in order that weeds may be kept down. (6) The acreage devoted to the money or cash crops should be such as may be maintained in the best condition for their production. Grass crops should appear in each field every 4 to 8 years. Cultivated crops and manure should appear one or more years in the same period. Grain may be grown in the rotation the remaining years.

FIG. 537. Test plots showing winter killing of a strain of wheat unadapted to the locality (*left*), and resistance of a better chosen, improved strain.

Manure in the rotation. Manure may be best applied, as a rule, to the intertilled crops. Corn, potatoes, root crops, etc., will generally make the best use of manure and leave the soil, to which the manure has been applied, in good condition for the grain crop which follows. The next best place to apply manure is on the grass crop. Manured meadows and pastures produce wonderfully from year to year. If the grass crop to which the manure is applied can be followed by corn or a root crop, it is almost an ideal system. The manure may be hauled upon the grass lands at any time and is immediately utilized.

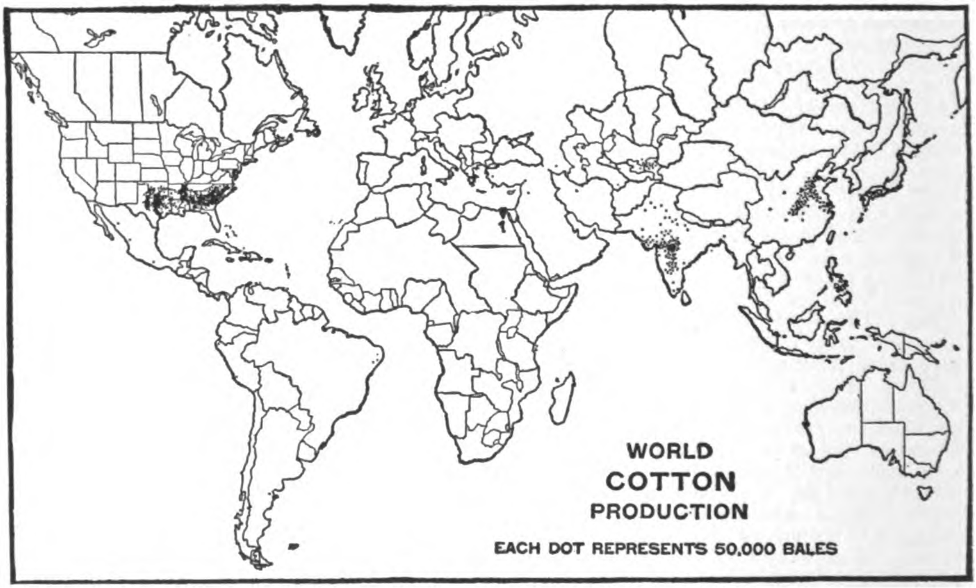
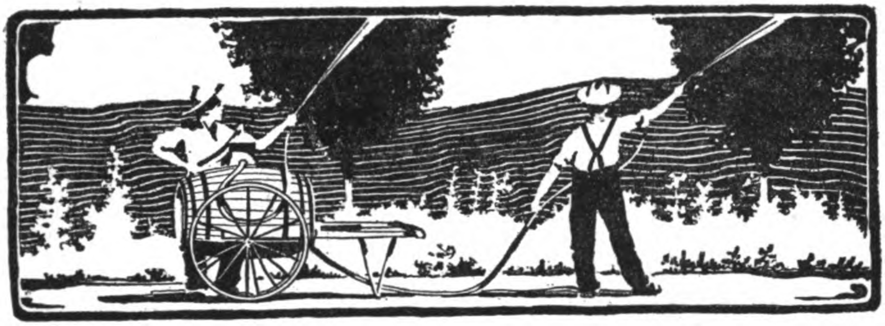


FIG. 538. The United States produces about three fifths of the world's cotton (p. 298). By continuing and even bettering its present methods of raising and improving the crop, it should greatly increase this figure in the future. (1916 Yearbook, U. S. Dept. of Agr.)



CHAPTER 32

Principles of Plant Injury and Its Control

By FREDERICK D. HEALD, *Professor of Plant Pathology, Washington State Agricultural College, whose wide experience along lines of agricultural botany, plant diseases, and plant protection has included the holding of important offices in Parsons College, Iowa; the University and the Agricultural Experiment Station of Nebraska; the University of Texas; the Chestnut Tree Blight Commission of the University of Pennsylvania; and the U. S. Department of Agriculture. This chapter explains and describes the ways in which insects and diseases can affect plants, and the general principles of the means that may be employed to combat them. It is a necessary, preparatory step, therefore, in recognizing the troubles and carrying out the recommendations listed in the following two chapters.*—EDITOR.

WHAT plant disease is. When the life of part of a plant or the whole of a plant is seriously threatened, that plant may be said to be in a diseased condition. Diseases may be *localized*, that is, they may affect only a very small part of a leaf, stem, or root; or they may be generalized or *systemic* when they may affect the entire plant. Again, disease may be defined as any failure of thrifty development or failure to produce a commercial product of satisfactory quality or quantity.

In order that a plant may make a thrifty development, certain essential conditions may be noted: (1) Proper inborn qualities of either seed or stock from which the plants are propagated. (2) Proper environmental conditions. These involve the right relation of moisture, temperature, and chemical composition of both soil and air; also a favorable light relation and the right physical composition of the soil. (3) Freedom from injurious influences, either mechanical influences or those due to the invasion of some parasitic organism. When we have deviations from the ideal or best conditions, disease may result. The diseased condition may be the result of the variation of one factor or of a combination of factors. For this reason, the final determination of the cause of a disease in any given case is often somewhat difficult. Plant diseases or troubles may be classified as follows:

1. **NON-PARASITIC.** Due either to wrong inherent qualities or to functional disturbances caused or modified by unfavorable environmental conditions, that is, deviations from the ideal in moisture, chemical composition, and temperature of either soil or air, physical properties of soil, in light relation, etc. Many of these troubles are as specific in their nature as are many diseases of men or domestic animals, as, for example, peach yellows, bitter rot of the apple, or blossom-end rot of the tomato; while others are less specific and are undoubtedly related to ill-chosen or poorly carried out agricultural or horticultural practices.

2. **PARASITIC.** Caused by various enemies:

Animal parasites. The larger number of animal parasites produce mechanical injuries by robbing the growing plant of a part of its

FIG. 540. Injury done by gophers around their burrow in a field of mangel beets

green, food-producing organs or by cutting off essential organs; in some cases, however, it is the plant product that is directly affected. While a few of the animal parasites are microscopic in size and are either buried in the plant tissues or scattered over its surface, the greater number are sufficiently large to be easily seen with the naked eye. They may be grouped as follows:

(a) Higher animals, including gophers, rabbits, mice, etc.

(b) Arthropods, or insect-like organisms including crustaceans, like the sow bug, mites of various kinds (red spider for example), and large numbers of true insects.

(c) Mollusks, including snails and slugs.

(d) Worms, represented by the root-infesting nematodes.

Plant parasites. Most of these are microscopic in size and so escape the direct observation of the grower. Many troubles caused by them are therefore blamed by the farmer or gardener on excessive moisture, drought, high temperatures, etc., or to some visible insect pest. Plants which thus prey upon other plants and steal all or part of their food from the host or plant on which they are growing, may be groupėd as follows:

(a) Higher (seed) plants such as the dodders or love vines, the mistletoes, and the broom rapes, all of which are conspicuous and easily recognized. Their number is relatively small.

(b) Fungi which include by far the greater number of our plant parasites. They may live outside or inside the plant tissues and are microscopic in size except in the spore ("seed") stage in some of the higher forms which produce toadstools or bracket fruits. Rusts, smuts, mildews, scabs, blight, and rot, are some of the troubles caused by fungi.

(c) Slime molds. These low forms of life, that stand on the border line between the animal and plant kingdoms, furnish but few important disease-producing forms. The club root or finger-and-toe disease of cabbage and related plants and the powdery scab of potatoes are examples.

(d) Bacteria are responsible for many specific diseases in the nature of blights, wilts, rots, etc.

The parasites included under divisions (b), (c), and (d) are responsible for the diseases which are called infectious or contagious. Many are windborne; others are carried by the seeds of the host plants; still others are transported by insects or other animals; while many are spread by man himself.

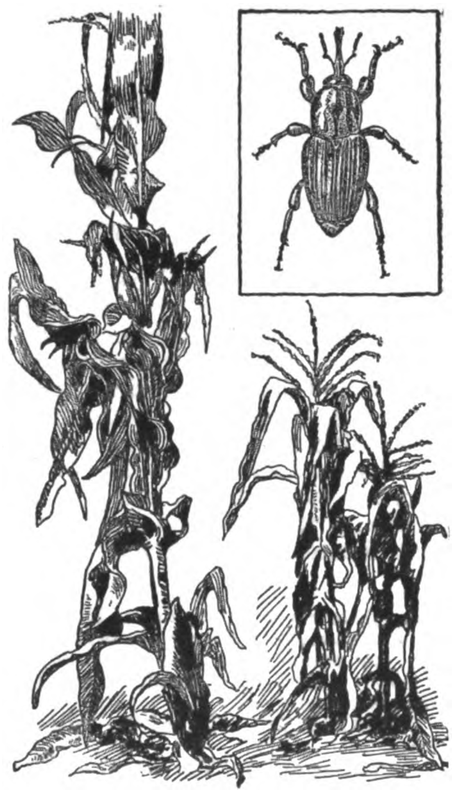


FIG. 539. Insects are the worst of the animal parasites of plants. Healthy corn plant (*left*) and one attacked by corn bill bugs (*right*). Bill bug enlarged (*inset*).

FIG. 541. The true army worm. *a* Adult (moth); *b* larva or caterpillar; *c* eggs laid by moth; *d* pupa or resting stage (in burrow).

Materials Used in Protecting Plants

Many chemical substances are used, according to directions given in Chapter 34, in either preventing or controlling the troubles caused by animal or plant parasites. Those used against the ravages of insects are called *insecticides;* those used against bacterial or fungous diseases are called *fungicides.*

FIG. 542. Oyster shell scale, a type of insect that can be destroyed only by a contact poison

INSECTICIDES. Chemical poisons used against insects are of three general kinds: (1) Poisons which must be eaten by the insects to give the desired results; (2) contact poisons which kill by striking and penetrating the soft body of an insect; (3) repellants or substances which, by odor or taste, serve simply to ward off attacks. The most important groups of insecticides are as follows:

Arsenical poisons, the principal ones being white arsenic, Paris green, London purple, arsenate of lead, and zinc arsenite.

Sulphur insecticides, including flowers of sulphur (sulphur flour) and lime-sulphur in various forms.

Emulsions, or oily or resinous sprays in which the active constituents are held suspended in water as minute globules by the addition of soap (just as butter fat is held in milk). These include the important contact insecticides for scale insects and plant lice such as the kerosene, distillate, and carbolic acid emulsions.

Miscible oils, which are really concentrated oil emulsions. They are intended primarily for use against San Jose scale and are fairly effective when diluted with 15 parts of water.

FIG. 543. A fungous parasite common on decaying trees.

Tobacco. The poisonous principle in tobacco is nicotine, a single drop of which is sufficient to kill a dog. Tobacco may be used as dust, as a home-made extract or decoction, or in the form of one of several commercial preparations; the most common and generally used is "black leaf 40."

Soaps. Homemade or commercial soaps may be employed as contact insecticides for plant lice or other small, soft-bodied insects.

Hellebore is a plant poison made from the roots of the white hellebore plant. It is less poisonous than the arsenicals and may be safely used on fruits when they are nearly ripe.

Bordeaux mixture. This copper-lime compound has been one of the most important fungicides, but it serves also against many insects, especially the flea beetles.

Hydrocyanic acid gas is very destructive to insect life and is a deadly poison, hence great care should be exercised in its use. It is extensively employed in grain houses, in the fumigation of citrus trees in the orchard, and for the general disinfection of nursery stock previous to shipment.

Carbon bisulphide is an oily, very inflammable liquid that evaporates rapidly. It may be used for killing insects in stored seed or grain, for the fumigation of tree cavities, etc.

FUNGICIDES. The essentials for a fungicide are:

(1) The chemical compounds employed must be comparatively inexpensive; (2) they must kill or prevent the growth of bacteria or fungous spores; and (3) the poison must be efficient at a strength which will not be injurious to the plant parts or structures to which the fungicide is applied. Many chemical compounds have important fungicidal properties but all but a few cannot be generally used on account of their cost or their failure to fulfil this third requirement. The principal fungicides in general use belong to the following groups:

Copper-containing compounds including

FIG. 544. When plants are few, or labor abundant and cheap, certain insects such as potato beetles can be knocked off and crushed. Let the children start a "bugging campaign."

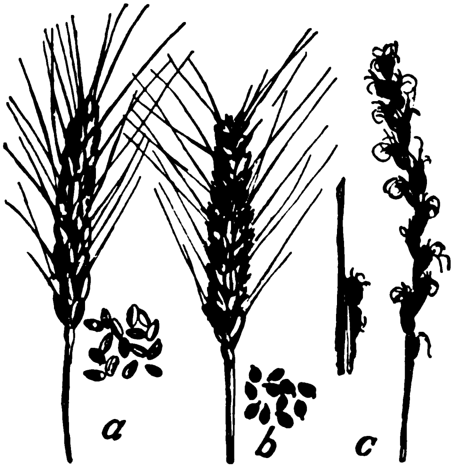


FIG. 545. Two forms of smut (a fungous disease) of wheat. *a* Healthy head, and grain; *b* head and grain infected with stinking smut; *c* heads showing effect of loose smut.

plain copper sulphate or blue stone, ammoniated copper carbonate, acetate of copper, Bordeaux mixture, soda Bordeaux, and Burgundy mixture.

Sulphur fungicides. Flowers of sulphur, sulphur flour or any brand of finely sublimed sulphur, potassium sulphide (liver of sulphur), and lime-sulphur in its various forms are the principal sulphur-containing fungicides.

Formaldehyde is a gaseous substance sold as a solution with a standard strength of 40 per cent "Formalin" is a trade name for formaldehyde produced by foreign manufacturers.

Corrosive sublimate (bichloride of mercury). This deadly poison may be bought in the form of powder, crystals, or tablets, and is readily dissolved in hot water. It is very effective for certain purposes, but it is dangerous to have about.

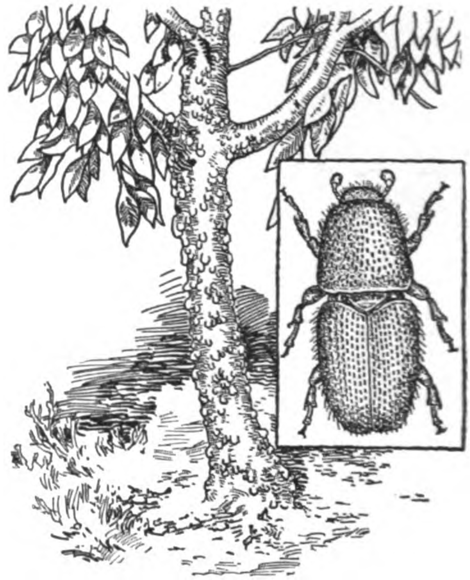


FIG. 546. Peach tree showing sap oozing from injuries made by peach tree bark beetle shown, enlarged, in inset.

Machinery for Plant Protection

Various mechanical devices are employed for the application of fungicides and insecticides in the form of a fine mist or spray. Early appliances consisted of a bundle of fine twigs and a bucket of the poison mixture, and even to-day a whisk broom may serve when only a few plants are to be protected. In recent years there has been a rapid advancement in the construction of spray machinery designed for special crops or suited to particular needs. The fact that poisons may be applied in liquid form (either in solution or in suspension), or in the form of a fine powder or dust, enables us to divide the types of spray machinery into two main groups as follows: *(See also Vol. III, Chapter 13)*.

LIQUID SPRAYERS. These vary chiefly in size, being in most cases some form of liquid or air-pressure pump.

Hand atomizers, of which there are various types, are adapted to spraying a few low plants in either house or greenhouse.

Bucket spray pumps are useful for small scale spraying operations in home gardens or small greenhouses. They may be operated in connection with any moderate-sized bucket.

Knapsack sprayers are to be strapped to the back of the operator, leaving both hands free, one to direct the spray nozzle and the other to work the pump. An agitator keeps the spray solution well mixed but a 5-gallon tank when full is tiresome to handle.

Hand compressed-air sprayers resemble knapsack sprayers and are much more convenient to operate. They lack an agitator and can be worked only intermittently.

Wheelbarrow sprayers are convenient forms for truck gardens or small orchards. The apparatus consists of a galvanized cylindrical tank holding 10 to 15 gallons, mounted

on an iron wheelbarrow frame and fitted with a small force pump. It requires two operators, one to work the pump and another to handle the spray nozzle.

Barrel sprayers are force pumps which may be attached to the side or end of 50-gallon barrels and mounted on a hand truck or wagon. One or two leads of hose may be attached for general or orchard work, extension rods being necessary for anything but very low trees. A row attachment may be connected for spraying potatoes or other row crops, but the spray hose in the hands of the operator is much more successful.

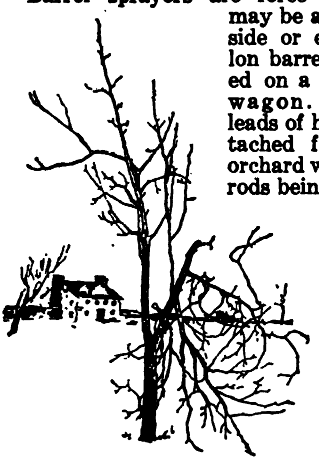


FIG. 547. Pear tree, here half of it killed by fire blight. The safest treatment is destruction of the entire tree.

Power sprayers are of various types, the force for driving the pump being obtained in several ways. Traction or sprocket power is, in one type, transmitted directly to the pump and, in another, used to compress air. One- or 2-horse types are available for either row or orchard work. In "gas" sprayers, the power is obtained from liquified carbonic acid gas. One- or 2-horse compressed-air sprayers, in which the compressed air is furnished from a central plant, are also available. In general, the most satisfactory power sprayers are those operated by gasoline engines. There are many improved types adapted for spraying forest or shade trees, commercial orchards or vineyards, or for extensive truck gardens; in cranberry bogs a spraying equipment consisting of a stationary engine and pump with permanent piping is frequently installed.

DUST SPRAYERS, a more recent development, are popular among some growers.

Simple powder guns may be used for dusting a few small or low plants in the house, greenhouse, or garden.

Hand dusters are operated by a fan driven by a crank, the small forms serving in the same places as knapsack or hand compressed-air sprayers; the larger machines may be mounted on small trucks or wagons.

Power dusters. The least expensive type is the sprocket power duster in which the power for operating the fan is obtained direct from the wheel. Dusters driven by gasoline engines are available for commercial orchards, vineyards, or nurseries.

Principles of Successful Spraying

Success in combating insect pests or preventing fungous diseases depends in large measure upon the following five factors:

The use of apparatus suited to the crop. The acreage and the nature of the crop must govern the selection of the style or make of sprayer.

The application of the spray mixture at the right time. A lack of sufficient attention here is the cause of many failures in actual farm practice, especially in treating for fungous diseases which must be prevented rather than cured. For example: spraying for peach leaf curl would do no good after the curled leaves show, since infection must be prevented by spraying some time before the buds open; the so-called "pink spray" (when the blossoms begin to show color), the most effective single application for apple scab, is of no value whatever in the treatment of black spot canker; against the codling moth no satisfactory results can be obtained if spraying is delayed until the calyx cup has closed, etc.

The selection and use of the proper material. In the first place, reliable information should be obtained as to the species of insect to be combated or the disease to be prevented. If the grower is in doubt, he should send specimens to his state experiment station for identification, so that he may apply the most efficient remedy. Lead arsenate, one of the most important insect poisons, is not efficient against flea beetles, a repellant like bordeaux being necessary. Lime-sulphur compound, the most important general insecticide and fungicide, should not be used for protecting potatoes against infections from either early or late blight, since it materially injures the plants. Bordeaux mixture has not been generally effective in the treatment of powdery mildew of the gooseberry, but lime-sulphur has given a satisfactory protection. Black-leaf 40, a contact insecticide,

is useless against leaf-eating insects like the tussock moth, or Colorado potato beetle, and so on.

Thoroughness of the application. A spray mixture, to be effective, must either reach the insects to be killed, cover the surfaces upon which they feed or the surfaces through which fungous infection is to take place. In general, the spray mixture should cover all parts of the plant to be protected, and special efforts should be made to reach the most difficult places. Do not try to economize in the use of the spray mixture. In orchard spraying, if the trees have reached any considerable age, a tower and extension rods must be employed in order to reach the tips of the highest branches. Use crook joints so as to spray from either above or below according to need.

The use of high pressure whenever possible. Whenever penetration is required, high pressure will give the best results. This is notably true in spraying for codling moth in which effective control depends on driving the poison mixture into the calyx cup. For general orchard spraying, a pressure of 150 to 250 pounds should be employed.

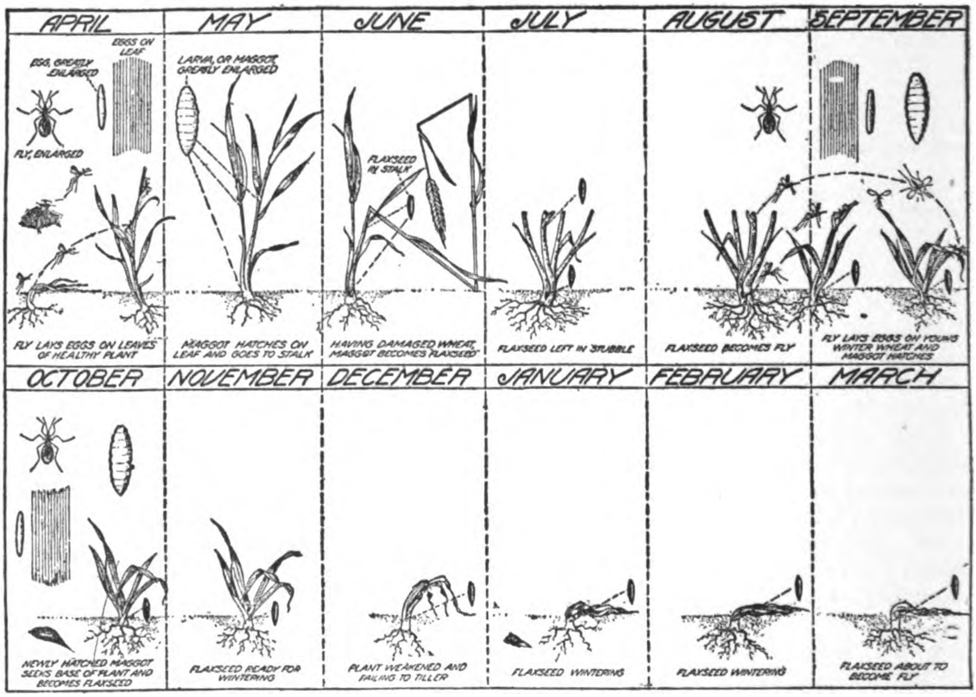


FIG. 548. Diagram showing seasonal development of the Hessian fly, a serious wheat pest. (Farmers' Bulletin 835.)

Suggestive General Spray Programs for Typical Crops

APPLE

1. **When the buds begin to swell.** Use an oil spray or lime-sulphur, winter strength. This is a general clean-up spray for scale, insect eggs, etc., and is especially important whenever San José scale is present.

2. **When the cluster buds have separated and show pink.** ("Pink spray.") Use lime-sulphur, summer strength, for scab and other fungous troubles. If leaf-eating insects like the bud moth are present, add arsenate of lead in the proportion of 2 pounds to 50 gallons. If mites, thrips, or aphids are troublesome, add black-leaf 40 or other 40 per cent nicotine at the rate of 1 part to 1,000 of the spray mixture.

3. Just after the petals have fallen. ("Calyx spray.") Use lime-sulphur, summer strength, adding 2 pounds of lead arsenate to each 50 gallons. This is the second scab spray and the first and most important codling moth spray. Additional applications of lime-sulphur must be given for scab, at least in the more humid regions. A second spraying for codling moth should be made when the moths are depositing eggs or just as the earlier worms are ready to enter the fruit. In the Pacific Northwest apple anthracnose requires a spraying with bordeaux 6-6-50 as soon as possible after the fruit is harvested. If the disease is especially severe, an earlier spraying should be made as soon as the fall rains begin. In regions where bitter-rot is prevalent, other applications of fungicide besides the 2 scab sprays will be necessary. For this trouble, use bordeaux 5-5-50 about 40 days after the petals fall and repeat at intervals of 2 weeks (giving 3 to 4 sprayings). In regions where powdery mildew is severe, special spraying with lime sulphur, atomic sulphur or iron sulphide may be necessary.

PEACH

For scale and leaf curl spray with winter strength lime-sulphur just after the buds begin to swell, but before they show any green color.

For California blight spray with bordeaux mixture or lime-sulphur, winter strength, about November 1. If this does not control the fruit spot, spray also in the spring after the fruit has set with 8-8-50 self-boiled lime-sulphur and repeat after an interval of 3 weeks.

For brown rot scab and curculio spray with self-boiled lime-sulphur: (1) Three to 4 weeks after the petals fall; (2) midway between (1) and (3); (3) about 1 month before the fruit is mature. If the curculio is present, add lead arsenate to the first spray and in regions where it is severe, use lead arsenate alone about 10 days after the petals fall.

POTATO

For early blight, late blight, flea beetle, and Colorado potato beetle spray with bordeaux 5-5-50 to which 1 or 2 pounds of lead arsenate have been added: (1) When the plants are 6 to 8 inches high (if the Colorado potato beetles are absent, omit the lead arsenate); (2) again after an interval of 2 weeks; (3) later sprayings for one or more of the troubles may be necessary; in general, 2 to 5 sprayings are required, the exact number varying with local conditions. *Under no condition use lime-sulphur for spraying potatoes.* For flea beetles alone, use bordeaux only and for Colorado potato beetles alone, use lead arsenate as soon as the young bugs appear.

FIG. 549. Melon vine infected with wilt, a usually fatal type of disease on many plants

FIG. 550. Apple rust is one stage of the disease that causes the galls or "apples" on cedar. Don't let cedars grow near apple orchards.

ASPARAGUS

For rust spray with flowers of sulphur or other sulphur dust preparation (using some type of dust sprayer): (1) Two to 3 weeks after cutting has been discontinued; (2) one month later; (3) again after 1 month. In some cases, the first and second applications may suffice. About half a sack (55 pounds) to the acre should be used at each application.

GRAPE

For powdery mildew spray with flowers of sulphur or other finely divided form of sulphur (using a dust sprayer): (1) When the blossoms begin to open if the mildew was serious during the preceding season, an earlier dusting should be given when the young shoots are 6 to 8 inches long; (2) later, while the grapes are still small and, if possible, before the first sign of mildew.

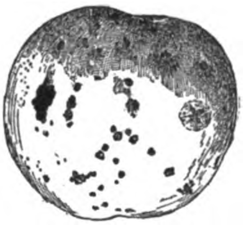


FIG. 551. Apple affected with scab—troublesome but rarely serious.

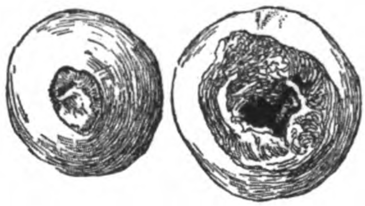


FIG. 552. Tomato end or stem rot is one of the commonest yet least understood of all the diseases of vegetables.

The Effects of Disease

The most prominent symptoms of disease in plants are described in Chapter 33. Here, it may be well to note the more important general effects of disease from the standpoint of plant production which are:

The destruction of the entire plant (death), which may be noted in both annual and perennial plants. Notable examples are the "damping off" of seedlings resulting in thin stands; wilt diseases of certain herbaceous plants like cucumbers or squashes; fruit or stem rots of herbaceous or woody plants; and blights of the more severe type. Examples of the latter are the fire blight of apples and pears, and the bark disease of the American chestnut.

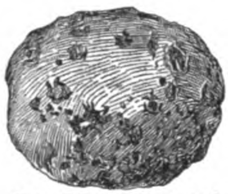


FIG. 553. Potato scab must be fought through the seed, not by spraying.

The destruction of the fruit. The most important illustrations are the rots of either pome or stone fruits (which are due generally to fungi), and the smuts of cereals in which the head is completely or partially destroyed.

The prevention of fruit setting. This is illustrated in blossom blight, due to various causes, in which the flowers are formed but blight; in other cases the blossom buds may be killed previous to the blossoming period.

The dropping of fruit. In this case the fruit sets and drops some time before maturity. This may be the result of insect pests, fungous diseases, or non-parasitic troubles such as self-sterility or lack of vigor.

Reduction in yield. This is especially prominent as a result of the rusts and smuts of our cereal crops. Insect pests, like the Hessian fly or aphis, may have a similar result.

Lowering in grade or quality. Among many possible illustrations are fruits like the apple which are affected by either scab or codling moth. When rusts or smuts are present in our grain field in any considerable amount, the crop produced is of an inferior quality. Tubers or root crops may have their market value and keeping qualities lessened by the attacks of either insects or fungi. Even the products of our forests are injured by the work of borers, and heart or sap rots may lessen the value of standing trees for lumber.

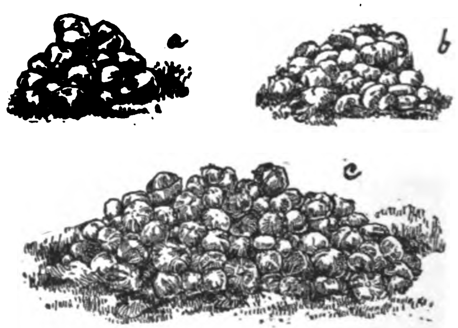


FIG. 554. Club root reduces cabbage yields; but lime reduces club root, especially if applied well ahead of planting. *a* Yield of unlimed plot; *b* from same-sized plot limed in spring; *c* from a third plot limed two years before. (Va. Bulletin 191.)

Early blight of the potato

CHAPTER 33

Plant Diseases and Insect Enemies:

Tip burn of the potato

How to Recognize and Control Them

By PROFESSOR F. D. HEALD *(see Chapter 32), who, in the course of his 20 years of teaching and investigational work in Michigan, South Dakota, Wisconsin, Iowa, Nebraska, Texas, Pennsylvania and Washington, has also been Collaborator, Expert, and Agent in Plant Diseases for the U. S. Department of Agriculture. At all time he has been in touch with practical plant production as well as the scientific study of diseases and pests; this, together with the farm life of his boyhood and his present operation of a small home farm, has given him what he calls "a familiarity with agricultural practice not gleaned entirely from books." He is eminently well equipped, therefore, to present to farmers, in a manner that they can fully understand and make use of, a subject that is very closely related to their success and their profits.*

The plan of this chapter is simple and wholly practical. The crops are listed alphabetically; under each is given, in the first column, the symptoms of the trouble—the actual signs that the farmer sees. The second column names the trouble, whether disease, injury, or insect; the third gives the scientific name of the cause and classifies it according to its nature. The fourth column lists the means of control or prevention, the letters and figures referring to those in Chapter 34 in which the detailed treatments are described. In other words, the troubles that affect plants are here identified and treated according to the same system employed in discussing animal diseases in Volume I. To the best of our knowledge, this is the first time this subject has been treated accurately, completely and with the needs and limitations of the practical farmer given first and greatest consideration.—EDITOR.

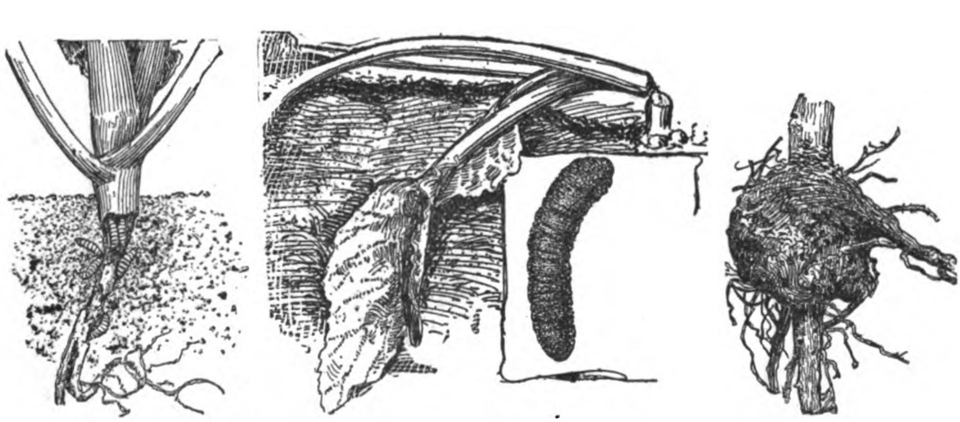


FIG. 555. Some representative plant injuries caused by insect enemies or disease. At top of page, two common fungous troubles. Here cabbage maggots (*left*); a cut worm and the seedling it has destroyed (*centre*); and an old crown gall on the apple—a bacterial disease (*right*).

Numbers and letters in last column refer to measures described in Chapter 34, pp. 503 to 525.

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
ALFALFA (Diseases)			
Yellow stunted plants	....	Acid soil	VI, Ha + inoculation
Yellow foliage, poor growth; corrosion of crown; death of plants	....	Alkali soil	VIII, F
Watery streaks on young stems exudate later; old stems blackened and brittle; leaves also blighted	Bacterial blight	*Pseudomonas medicaginis* (Bacterium)	XI, Bb; IX, A
Lower leaves yellow, developing minute black specks; leaflets curl and fall off	Blight	*Pyrenopeziza medicaginis* (Sac fungus, imperfect stage)	IX, A
Yellow or reddish leafless vines twining around or over plants	Dodder	Cuscuta sp. (Flowering plant)	II, Aa; XI, A or VI, F, if severe and general
Terminal tender shoots drooping and wilted, later discoloring	Frost	Frost	XI, Bb, for frost resistance
Leaves curled and puckered, lower epidermis loose	Frost blisters	Frost	"
Yellow blotches on upper side of leaves or entire leaflet yellow, dirty gray and powdery below	Downy mildew	*Peronospora trifoliorum* (Downy mildew fungus)	IX, A
Leaves with small circular brown spots, later yellow and defoliated	Leaf spot	*Pseudopeziza medicaginis* (Sac fungus)	IX, A
Irregular gray or brown dead areas on leaflets including black spore dots	Leaf blight	Ascochyta sp.	IX, A
Leaflets showing brown or black powdery spore dots	Rust	*Uromyces striatus* (Rust fungus)	IX, A if severe.
Irregular knotty outgrowth from crown or main roots	Root gall	*Urophlyctis alfalfae* (Pond scum parasite)	No remedy known. XI, Ad
Cottony growth over lower portion of stems, yellowing and wilting of plants, small black bodies in hollow of diseased stems	Wilt	*Sclerotinia trifoliorum* (Sac fungus)	IX, A, or, if general and serious, VI, F
Plants normal in fall, dead or make poor growth in spring	Winter injury	Low temperature and tender varieties	XI, Bb
Tops of plants with yellow sickly foliage	Yellow top	Poor soil	VIII, C or VI, Hb
Plants dying in ever widening circular spots; weft of violet fungous threads on roots	Violet root rot	*Rhizoctonia crocorum* (Sterile fungus)	VI, F if general; X, Cc if in spots
Plants wilt and die, brown weft of fungus on roots	Southern root rot	*Ozonium omnivorum* (Sterile fungus)	VI, F + VI, Ab

ALFALFA (Insects). See clover leaf weevil, and clover seed chalcid-fly under *clover insects;* army worms, and grasshoppers under *field crops, general insects;* cut worms under *garden crops.*

Naked dark green worms eating the leaves	Alfalfa caterpillar	*Eurymus eurytheme* (Butterfly)	IX, A + VI, B
Grubs ($\frac{3}{8}$ inch) eating tender leaves and crown; later snout beetles ($\frac{1}{8}$–$\frac{3}{16}$ inch long) eat freshly expanded leaves and stem	Alfalfa leaf weevil	*Phytonomus posticus* (Snout beetle)	VI, Bb; VI, Bc; VI, F after 6 yrs.; V, G
Yellowish worms ($\frac{1}{2}$–$\frac{3}{4}$ inch) skeletonize leaves and spin webs over plants	Garden webworm	*Loxostege similalis* (Moth)	VI, Bb; V, C. (pigweed)
Olive green caterpillars, with three dark longitudinal lines, eat foliage	Alfalfa semi-looper	*Phytometra californica* (Moth)	Checked by natural enemies
Dirty white or light brown maggots "leather jackets" ($\frac{1}{2}$–1 inch) feeding on the roots	Alfalfa crane fly	*Tipula simplex* (Cranefly)	V, F
Small, pale yellow spots on foliage	Stigmonose	*Frankliniella tritici* (Thrips)	V, F since III, F or V are impractical
Tap roots with circular or elongated corroded areas, giving cortex a scabby appearance	Clover root curculio	*Sitones flavescens* (Snout beetle)	VI, F, Bc

ALMOND. See crown-gall, Cercospora leaf spot and yellows under *peach diseases;* mushroom root-rot under *apple diseases;* the clover mite under *clover insects;* the western peach root-borer under *peach insects;* the pear thrips under *pear insects.*

APPLE (Diseases). Diseases affecting *leaves, twigs,* or *branches* and *fruit* (sometimes *blossoms*).

Circular brown spots or frog-eye spots on leaves. Brown or dark rotting areas on fruit, covered with minute black pustules and later producing a "mummy"	Frog-eye Black-rot, Leaf spot	*Sphæropsis malorum* (Imperfect stage of *Physalospora cydoniæ*) (Sac fungus)	V, I and K; III, A or F
Blighting back of terminal twigs, cankers on larger limbs	Blight Black-rot canker		" "
Leaf spots irregular, gray, light brown, or yellow, 1/16 inch or less in diameter, with one to several minute black pustules	Blotch, Leaf spot	*Phyllosticta solitaria* (Imperfect fungus)	III, Ad 1. 3 weeks after petals fall 2. Again after 4 weeks 3. Repeat after 3 weeks
Similar spots or small cankers on twigs and young branches	Twig canker		
Fruit spots with minute black margin irregular, 1/4 inch or more in diameter, relatively superficial	Fruit blotch		
Blossoms brown or blasted	Fire blight Blossom blight	*Bacillus amylovorus* (Bacterium)	V, I and K or H if severe
Leaves with marginal or terminal advancing brown areas	Leaf blight		XI, Bb III, V for aphids if present
Twigs killed back, leaves brown and drooping	Twig blight		
Depressed circular black spots on fruits, no pustules	Fruit spot		
Brown rotting areas (1 or 2) advancing until whole fruit is rotting, exudate formed	Fruit blight		
Cankers or lesions on branches or trunk	Body blight or cankers		
Lesion, that is dead cortex at crown	Collar rot or blight		
Leaf spots, yellowish above with few black pustules; lower surfaces swollen, later covered with minute cups with recurved edges. Similar structures on fruits, causing reduction in size and irregularity. Twigs less frequently affected	Scab Leaf rust	*Gymnosporangium juniperi-virginianæ* (True rust fungus)	V, B or D (cedar trees) III, A but of doubtful commercial value
Leaf spots irregular, dark olivaceous, thickening with age, or affected portion covered with continuous layer of brown spores. Fruits reduced in size, deformed or only spotted. Young spots dark velvety olivaceous, older spots brown and corky. Twigs less frequently affected, spots similar to those in the fruit		*Venturia inæqualis* (Sac fungus)	III, F. See spraying schedule in Chap. I
Leaves rolled or curled, covered with white powdery coating, reduced in size, dropped Twigs when young with white powdery coating, later becoming brown due to numerous black fungous fruits. Fruit and blossoms sometimes affected	Powdery mildew	*Podosphæra leucotricha* (Sac fungus)	III, E, F, or I; V, I

Diseases affecting *branches* and *fruit.*

Fruits rotting rapidly with approaching maturity, brown depressed rotting areas soon showing pink spore pustules in circular or concentric zones	Bitter rot, Ripe rot	*Glomerella cingulata* (Sac fungus)	III, A or F 1. 6 weeks after petals fall 2. Repeat at intervals of 2 weeks. V, K, J
Bark cankers on larger limbs (may be absent), perennial	Bitter rot canker		
Bark cankers elliptical, with maturity producing spore pustules which are transversely elongated. Fruit rot slow, affected spots brown or dark, late maturity or storage. Peculiar to Pacific Northwest	Apple anthracnose, Black spot canker	*Neofabræa malicorticis* (Sac fungus)	III, Ae (1) After fruit is picked (2) Repeat if severe

Diseases affecting *fruit only.*

Fruit rotted (soft rot):			
Completely rotted, brown or black with or without superficial cottony growth	Brown rot	*Sclerotinia fructigena* (Sac fungus)	III for scab, etc. IX, B, D
Completely rotted, light or dark brown			
Producing superficial bluish green spore tufts	Blue mold	*Penicillium expansum* (Imperfect fungus)	IX, B, D, F
Producing grayish powdery spore tufts	Gray mold	*Botrytis cinerea* (Imperfect fungus)	IX, B, D, F
Fruits with localized spots of dead brown tissue. (Dry or spongy rot).			
Sunken somewhat circular, dead spots, superficial and also internal:	Bitter pit, Stippen, Baldwin spot	Non-parasitic	VII, A or B; IX, D, H
Circular depressed brown spots, never internal. 1/8—1/4 inch diameter	Jonathan spot	Non-parasitic	IX, D, H
Irregular depressed areas variable in size, but larger than Jonathan spot	Drought spot, Spot necrosis	Non-parasitic Intermittent water supply	VII, B

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Circular depressed rotting spots beset with minute black, spiny spore fruits. (Later may involve large areas)	Spongy dry rot	*Volutella fructi* (Imperfect fungus)	IX, B, D
Spots with superficial, pink, or rose-colored mold, frequently related to scab spots. Spreading later	Pink rot	*Cephalothecium roseum* (Imperfect fungus)	Control of Scab; IX, B, D
Fruits with superficial sooty mold or small black specks	Sooty blotch and Fly speck	*Leptothyrium pomi* (Imperfect fungus)	Last spraying for scab, or bitter-rot sprayings
Fruits with numerous minute superficial spots, red, brown or black, later penetrating flesh slightly, but remaining small	Fruit spot	*Phoma pomi* (Imperfect fungus)	III, A or F late in June or early in July
Fruits with portions of surface russeted			
Equatorial russet band	Belted fruits	Frost	X, H
Diffuse russeted areas	Frost russeting	"	
	Bordeaux injury	Spray injury	Use lime-sulphur
Fruits watery at core or in other parts of pulp	Water core	Non-parasitic High-water pressure	VII, A; VI, D
Diseases affecting *leaves only*.			
Leaves puckered or rolled, lower epidermis splitting from the internal green tissue	Frost blisters	Low temperatures	X, H; XI, Bb
Leaves drooping, matted, later brown, covered on lower surface with brown fungous weft	Hypochnus leaf blight	*Hypochnus ochroleuca* (Basidium fungus)	III, A. Before buds (1) leaf and (2) blossom, open.
Diseases affecting *roots, crown,* or *branches*.			
Cankers produced on branches or trunk. (See also Bitter rot, Blotch, Black rot, Fire blight, and Black spot canker). Canker perennial with concentric zones of callus	European canker	*Nectria galligena* (Sac fungus)	V, J, K
Canker with disk-like or nail head-like black fungous fruits	Blister canker	*Nummularia discreta* (Sac fungus)	V, L, J, K
Canker with very roughened bark, spreading to involve extended areas. (See also Rough bark disease)	Rough bark canker	*Phomopsis mali* (Imperfect fungus)	Reject Yellow Newtown
Cankers or lesion relatively smooth, generally on southwestern side of limb or axis (Fungus pustules may develop later)	Winter sunscald	Alternate freezing and thawing	X, Da; VII, A
Cankers little depressed, fungus pustules open	Bark canker	*Myxosporium corticolum* (Imperfect fungus)	None necessary
Abnormal tumor-like outgrowths on roots or crown (sometimes on aërial branches)	Crown-gall	*Pseudomonas tumefaciens* (Bacterium)	Wrapping grafts, V, H (nursery stock). Selection of scions.
Bark dying at crown, localized dead zone, no abnormal outgrowths. Sparse foliage of poor color and yellowish brown bark. (See also collar rot due to fire blight)	Collar rot	Winter injury	VII, A; VI, D in irrigated orchards. V, I + bridge grafting
General death of bark of roots and crown.		*Armillaria mellea*	V, E, H, N; X, Cc
Brown-shoestring strands of fungus running over the affected parts	Mushroom root rot	*Clitocybe parasitica* (Basidium fungi)	V, E, H, N; X, Cc
Brown weft of fungus on roots	Ozonium root rot	*Ozonium omnivorum* (Sterile fungus)	V, E, H, N
Abnormal production of large number of fibrous roots; general or producing tufted knot or lateral broom-like bunches	Hairy root	*Pseudomonas tumefaciens* (Bacterium)	V, H (nursery stock)
Disease *systemic* (affecting the *entire tree*). **(Sometimes localized.)**			
Tree normal in fall, parts or entire tree fails to grow in spring or produces clusters of undersized leaves, which die or fail to reach normal size	Winter injury	Low temperatures. Too little water. Too much water	VII, A or B; XI, Bb; VIII, Ca
Slender, partially defoliated limbs and clusters or rosettes of leaves; later death of limbs or entire tree	Rosette	Improper soil conditions	VI, D (alfalfa); VIII, A or C
Circular raised dead spots on smooth bark of twigs or branches, with later death of limbs or entire tree	Brown bark spot	Poor soil	VIII, A or Ca and c

Rough bark general, reduced vigor, small poorly-developed fruit	Rough bark disease	Poor soil	VIII, A or C
Bark normal but leaves with silvery gray color, little or no fruit, death of limbs or sometimes entire tree	Silver leaf	*Stereum purpureum* (Basidium fungus)	V, E, G, H, I, J; Avoid diseased nursery stock

APPLE (Insects). See also pear-leaf blister mite, pear blight beetle, and Howard scale under *pear insects;* American plum borer, European fruit-tree scale, and European fruit Lecanium under *plum insects;* fruit-tree bark-beetle, and terrapin scale under *peach insects;* walnut scale under *currant insects;* imbricated snout beetle under *strawberry insects;* and rose chafer and cottony maple scale under *grape insects.*

Insects affecting the *fruit*. See also scale insects, etc.			
Maggots (*larvae*) make burrows or channels in pulp			
Channels very irregular and numerous			
Larva [illegible] inch; adult a moth	Apple fruit miner	*Argyresthia conjugella*	III, K ?
Larva [illegible] inch; adult a fly	Apple maggot	*Rhagoletia pomonella* (Fly)	III, K (See schedule for apple in Chap. 27)
Channels single. Deep or around the core	Codlin worm or moth	*Carpocapsa pomonella* (Moth)	III, K, as for codlin worm; second spraying, 3-4 wks after petals fall the most important
Knotty or gnarly fruit or marked with punctures.			
Punctures marked with crescent, tissue removed	Plum curculio	*Conotrachelus nenuphar* (Snout beetle)	V, G; VI, C; III, K as for codlin worm + more applications if severe.
Punctures simple, round, tissue removed	Apple curculio	*Anthonomus quadrigibbus* (Snout beetle)	" "
Punctures, simple; sucking punctures only	Apple red bugs	*Heterocordylus malinus Lygidea mendax* (Bugs)	III, V, 1 pint to 100 gals. just before blossoms open
Not localized	" "	" "	" "
More abundant toward calyx end	Stigmonose	Various Species (Plant lice)	III, V, [illegible] pint to 100 gallons when buds are opening.
Insects affecting the *buds* or *leaves*.			
Eating the buds.			
Caterpillar eating the central expanding leaves or flowers of a bud and later drawing them together to make a nest			
Dark brown, [illegible] inch long	Bud moth	*Tmetocera ocellana* (Moth)	X, F (nests); III, K, 2-50, before flower clusters appear and later before they open
Yellowish green, [illegible] inch long	Fringed-wing apple bud moth	*Holcocera maligemella* (Moth)	" "
Caterpillar dark flesh-colored, [illegible] inch long, deserting the terminal bud nest for wooly tubes on the leaves	Apple bud worm	*Exartema malanum* (Moth)	V, I; III, K in June
Beetles eating buds before opening			
Small snout beetles	Bud weevils	Various species (Snout beetles)	X, C a
Other beetles	Bud beetles	Various species	X, Bf

Eating the expanded leaves. See aphids and mites which suck the juices.

Caterpillars in colonies and protected by a web			
Adults 1[illegible] inches, with broad dusky stripe along the back, web covering leafy branches	Fall webworm	*Hyphantria cunea* (Moth)	V, I and burn; X, E, Arsenicals generally control it
In web in forks of branches			
Adults (2 inches) with continuous median white line	Apple tree tent caterpillar	*Malacosoma americana* (Moth)	III, K as for codlin worm V, C (wild cherry)

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Adults similar but with row of bluish spots in median line	Western tent caterpillar	*Malacosoma fragilis* (Moth)	" "
In light web over partly eaten leaves (½ inch long) (also eats young apples)	Palmer worm	*Ypsolophus ligulellus* (Moth)	III, K when first appears
Caterpillars in colonies, but without a true web or tent			
Row of cream-colored spots in median line	Forest tent caterpillar	*Malacosoma disstria* (Moth)	III, K, 8-100 while larvae are small; X, Ca; V, I (twigs with egg masses)
Neck yellow, and sparsely clothed with long white hairs. Body striped with black and yellow	Yellow-necked apple caterpillar	*Datana ministra* (Moth)	III, K; jar off from small trees
Body striped with black and yellow or whitish lines, a prominent reddish hump on the fourth segment	The red-humped apple caterpillar	*Schizura concinna* (Moth)	III, K; jar off from small trees
Body pale green, conspicuous saddle-shaped mark on 3d to 4th abdominal segments	The saddled prominent	*Heterocampa guttivitta* (Moth)	III, K; X, Ca if adjacent to infested woodland
Caterpillars mining within the leaves			
Narrow, tortuous mines ¾ inch long	Ribbed cocoon-maker	*Bucculatrix pomifoliella* (Moth)	III, F, Q (1-10) or S (1-1) during winter or early spring
Trumpet-shaped mines, white banded and broadening to blotches	Trumpet leaf-miner	*Tischeria malifoliella* (Moth)	VI, A (also early spring), C; III, V, 1-800
Mines not as above	Lesser leaf-miners	Various species (Moths)	VI, A (also early spring), C; III, V, 1-800
Caterpillars solitary or scattered, and protected:			
By silken web over a single leaf	Leaf skeletonizer	*Canarsia hammondii* (Moth)	III, K when first evident
In twisted tube (1 inch long) hidden among brown crumpled leaves	Leaf crumpler	*Mineola indigenella* (Moth)	X, F (winter nests); III, K just before and just after blossoming period
In rolled or folded leaf (leaf rollers):			
Opposite edges fastened together, larva ½ inch long, head yellow	Lesser apple leaf roller and apple leaf sewer	*Alceris minuta* (Moth) *Ancylis nubeculana* (Moth)	III, K when first leaves are unfolding III, K when first leaves are unfolding; also V, F or VI, C
Groups of young leaves rolled and fastened with silken hairs			
Larva ¾ inch, light green, head brown or black	Fruit tree leaf roller and Oblique banded leaf roller	*Archips argyrospila* (Moth) *Archips rosaceana* (Moth)	III, Q, 1-19 or N (10%) early in spring when trees are dormant, to kill eggs; III, K, 3-50 when buds begin to burst and when blossom buds begin to separate + CALYX SPRAY
Larva ½ inch, bright yellow	Four-banded leaf-roller	*Eulia quadrifasciana* (Moth)	
In small cases of silk or silk and leaf fragments:			
Cases cigar-shaped	Cigar-case bearer	*Coleophora fletcherella*	III, K as for bud moth
Cases pistol-shaped	Pistol-case bearer	*Coleophora malivorella* (Moth)	III, K as for bud moth
In large case of leaves and sticks fastened with silk	Bag worm	*Thyridopteryx ephemeraeformis* (Moth)	X, F (winter nests) or III, K after leaves open
Caterpillars solitary or scattered, and unprotected:			
Measuring or span worms without median hair tufts or tussocks, 1 inch long when mature, 2 pair front legs	Spring canker worm	*Paleacrita vernata* (Moth)	VI, C; X, Ca (cotton) or tanglefoot; III, K if others are not successful

3 pair front legs	Fall canker worm	*Alsophila pometaria* (Moth)	As for spring form except X, Ca in fall
1¼ inches long when mature, 10 narrow black stripes separated by similar yellow stripes, 3 pair front legs	Lime tree span worm	*Erannis tiliaria* (Moth)	Same as fall canker worm
8 pairs of narrow black stripes, 3 pair front legs	Half-winged geometer	*Phigalia titea* (Moth)	Same as fall canker worm
1½ inches long when mature, 2 pair front legs	White ennomid	*Ennomos subsignarius* (Moth)	III, K, 5-100 when first hatching
¾ inch long when mature, 2 pair front legs	Bruce's measuring worm	*Rachela bruceata* (Moth)	Same as fall canker worm
Caterpillars with pronounced hair tufts or tussocks: The four median tussocks white, head vermilion red	White marked tussock moth	*Hemerocampa leucostigma* (Moth)	X, Fa (egg masses) III, K 5 or 6-100 when young; X, Bf; X, Ca
The four median tussocks dark gray with brownish crests	California tussock moth	*Hemerocampa vetusta* (Moth)	Same
The first two median tussocks black in young larvæ, later all white, head black	Antique tussock-moth	*Notolophus antiqua* (Moth)	Same
Caterpillars plump, dull-colored and obscurely marked; climbing the trees at night only	Climbing cut worms	Various species of night-flying Noctuid moths	VI, C after July 15 X, Ca (cotton batting) X, F (use lantern); X, A a
Beetles eating the leaves: Minute jumping beetles, eating holes	Flea-beetles	Various species	III, A + K
Small, brown and slender; drop quickly and feign death if tree is jarred	Click-beetles	Corymbites spp. (Click beetle)	VI, Ba, X, Bf
Large, brown and plump; flying at night	May beetles or June bugs	Lacnosterna spp. (Beetles)	None effective except against the grubs

Sucking the juices of leaves or succulent twigs. (Aphids, leaf hoppers, mites.)

Soft-bodied, wingless, inactive bugs, feeding in colonies (winged forms develop later)	Plant lice		
Bright green in color	Apple leaf aphis	*Aphis pomi*	V, I (twigs bearing eggs; III, V 1-1000 before leaves curl, or dip tips in mixture
Yellowish-green, common on opening buds	European grain aphis	*Siphocoryne avenae*	" "
First spring forms dark purplish-brown, mottled with black, faintly white powdery; later forms generally pinkish with white coating	Apple bud-aphis Rosy apple aphis	*Aphis sorbi* (Plant lice)	" "
Minute, pale, winged and active insects; cause minute white spots which, if numerous, give a bleached appearance to the leaves	Apple leaf hopper	*Empoasca mali* (Leaf hopper)	III, V, before the winged forms appear
Minute spider-like (8 legs) insects (1-100—3-100 in.); affected foliage blanched or yellowish	Clover-mite Two-spotted mite or "red spider"	*Bryobia pratensis* *Tetranychus telarius* (Mites)	III, F, winter strength, or N (10%) S, 1-10, or I (dust) spray

Insects attacking the *blossoms*

Entering before open and gnawing so as to shrivel the blossoms; very minute, slender, light yellow insects	Thrips	*Thrips tritici* (Thrips)	See Pear thrips
Piercing the blossoms after opening; dull-colored, ¼ inch long	Tarnished plant bug	*Lygus pratensis* (Capsid bug)	V, F., G; VI, C, also hedges and fence rows

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Insects affecting primarily *twigs* and *branches*. *Fruits* and *foliage* to a lesser extent, also *roots* in case of wooly aphis.			
Flat or cushion-like and closely appressed to the bark. (Scale insects). Kill shoots and spot or deform fruit:			
Circular, largest 1/16 inch, diameter, surrounded by zone of red on fruits or green twigs			
Papilla central, dark	San José scale	*Aspidotus perniciosus*	IV, Dc; III, F, N, Q, dormant spray high pressure
Papilla to one side of the centre, yellow	Putnam's scale	*Aspidotus ancylus*	" "
Papilla often to one side of the centre, dark brown	Greedy scale	*Aspidotus rapax*	" "
Elongated oyster-shell in form, 1/8 inch long, bark color	Oyster-shell scale	*Lepidosaphes ulmi*	III, F (winter) or S 1-5 or V 1-1000 when young are crawling
Pear-shaped, flat, 1/8 inch, grayish white giving bark an ashy or scurvy appearance.	Scurfy scale	*Chionaspis furfura* (Scale insects)	" "
Bluish-white cottony patches consisting of small reddish-brown plant lice covered by wooly mass of long waxy fibers (also root inhabiting)	Wooly aphis	*Schizoneura lanigera* (Plant lice)	III, N (15%); X, Ia or b, in kerosene emulsion (15%); X, Ca, III T, or kerosene emulsion 15% for root forms
Branches scarred (but not killed) by egg punctures:			
Two curved slits close together in rows on upper side of branch; wound enlarging to make a circular callus (Insect triangular hump-backed, 3/8 inch long, green)	Buffalo tree hopper	*Ceresa bubalus* (Tree-hopper)	VI, C + clean borders and fence rows
Chain-like rows of punctures, enter the wood	Tree crickets	Oecanthus spp.	Ditto, + V, K
Elongated punctures with frayed or torn margin	Cicada	Tibicen spp. (17-year or dog-day locusts)	III, A as repellant; V, I or K
Small limbs or twigs amputated:			
Twig girdled to heartwood, girdled zone 1/8 inch wide, beetle working from outside.	Twig-girdler	*Oncideres cingulata* (Beetle)	V, I (fallen twigs in autumn)
Twig amputated by larva working on inside; the 3/4-inch white grub located in tunnel in near end of fallen branch	Twig pruner	*Elaphidion villosum* (Cerambycid beetle)	Same as for twig girdler
Larvae or adults living in the wood or bark and eating out burrows or tunnels (borers).			
Boring in the wood.			
At or near the ground level:			
Legless light yellow grubs 1 inch long when full grown	Round-headed borers	Saperda spp. (Cerambycid beetle)	III, N on trunk as deterrent; X Ca (tar paper around base of tree trunk) X, Da (carbolated); VI, C; X, Fb; IV, Bd
Grubs larger, with legs	Moth borer	*Zeuzera pyrina* (Moth)	IV,d B
Usually in the upper trunk or branches; grub legless with broad flat head	Flat-headed borer	*Chrysobothris femorata* (Buprestid beetle)	As for round-headed borers; put repellant washes on upper branches
In terminal twigs; enter terminal bud and bore down an inch or two; grub cream or pink, 1/4 inch long	Apple bud borer	*Epinotia pyricolana* (Moth)	V, I, terminal twigs with dormant caterpillars
In the twigs; enter axils and bore down into centre; grub whitish 2-5 inch long	Apple-twig borer Grape-cane borer	*Amphicerus bicaudatus* (Beetle)	V, I, the infested twigs
In twigs; pith and adjacent wood devoured; larva yellow about 3/4 inch long	Eye-spotted apple-twig borer	*Oberea ocellata* (Beetle)	V, I, the infested twigs

Boring in bark or between the bark and wood:			
Bark perforated with minute round holes, larvæ $\frac{1}{16}$ inch, tunnels extensive	Bark-beetle or shot-hole borer	*Scolytus rugulosus* (Beetle)	X, Da; V, I and general clean orcharding
Larvæ $\frac{1}{8}$ inch long, tunnels an inch or two long	Bronze apple-tree weevil	*Magdalis aenescens* (Snout beetle)	Repellant washes early in April and in May
APRICOT (Diseases)			
Spotting or shot-holing of foliage and stems spotted or cankered			
Fruits also spotted, older spots raised	California blight	*Coryneum beijerinckii* (Imperfect fungus)	See peach
Fruits also spotted, older spots not raised, brown	Scab or Freckle	*Cladosporium carpophilum* (Imperfect fungus)	See peach
Fruits also spotted, older spots not raised, black	Black spot or Bacterial spot	*Pseudomonas pruni* (Bacterium)	See peach
Fruits rarely spotted, foliage with numerous brown or yellowish granular spore dots	Rust	*Tranzschelia punctata* (Rust fungus)	See peach and plum
A pronounced yellowing and curling of the leaves followed by defoliation and death.	Yellows	Non-parasitic	See peach
Leaves of ashen gray or silvery color, little or no fruit, death of limbs or entire tree.	Silver leaf	*Stereum purpuream* (Basidium fungus)	See plum and apple
Blighting back of twigs or branches without leaf spotting			
Terminal twigs and leaves blighted during growing season	Fire blight	*Bacillus amylovorus* (Bacterium)	See apple and pear
Cankers produced on trunk, branches or twigs	Die-back	*Valsa leucostoma* (Sac fungus)	See peach
Trees healthy in fall, entire tree or parts fail to grow in spring	Winter injury	Non-parasitic	See winter injury and collar rot under apple
Irregular tumor-like enlargements on crown or roots	Crown gall	*Pseudomonas tumefaciens* (Bacterium)	See apple
Black elongated enlargements on the branches	Black knot	*Plowrightia morbosa* (Sac fungus)	See plum
Fruits rotted on the tree or after picking; blossoms and tender shoots sometimes blighted			
Cottony mold developing on affected parts; never powdery	Cottony rot	*Sclerotinia libertiana* (Sac fungus)	Same as for brown rot
Tawny fungus from affected parts; powdery spore tufts	Brown rot	*Sclerotinia laxa* (Sac fungus)	III, G when fruit is setting and later according to need

APRICOT (Insects). See peach-tree borer, Pacific peach-tree borer, fruit-tree bark beetle and the white peach scale under *peach insects;* the plum curculio, European fruit-tree scale, European fruit Lecanium under *plum insects;* the pear thrips under *pear insects;* the clover mite, red spider, flat-headed apple-tree borer, round-headed apple tree borer, San Jose scale, oyster-shell scale, red-humped apple caterpillar, fall cankerworm and the fruit-tree leaf roller under *apple insects;;* the cherry scale under *cherry insects.*

Brown beetles ($\frac{1}{16}$ inch) feeding in the foliage	Apricot leaf weevil	*Paraptochus sellatus*	X, Bf; X, C
ARTICHOKES			
Leaves showing yellow blotches, powdery below	Mildew	*Plasmopara halstedii* (Downy mildew)	III, A or F
Abundant brown or black spore dots on leaves	Rust	*Puccinia helianthi* (Rust fungus)	V, G; VI, F
ASPARAGUS (Diseases)			
Spore pustules showing on stems or false leaves; orange yellow, brown, or black; shoots yellowing early in season	Rust	*Puccinia asparagi* (Rust fungus)	See spraying schedule in Chap. 32
Black spore pustules on a blanched background	Anthracnose	Colletotrichum sp. (Imperfect fungus)	Not serious
Stems with ashen-gray, dark bordered spots	Leopard spot	Unknown	Not serious

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
ASPARAGUS (Insects)			
Grayish grubs or adult beetles eating tender shoots or feeding on older plants			
Adults ¼ inch, wing covers yellow bordered and marked with dark blue . . .	Common asparagus beetle	*Crioceris asparagi*	X, Be; III, K (mature plants)
Adults ¼ inch, wing covers or angel six black spots on each	12-spotted asparagus beetle	*Crioceris duodecimpunctata* (Beetles)	X, Be; III, K (mature plants)
Blackened spots on stem, containing either flaxseed pupa or a footless white maggot (1-5 inch); stems sometimes girdled and killed	Asparagus miner	*Argromyza simplex* (Fly)	X, Be early and late; also V, I
AVOCADO (Disease)			
Defoliation; spotting and cracking of fruit	Anthracnose	*Colletotrichum gloeosporioides* (Imperfect fungus)	V, I; III, A
BARBERRY (Disease)			
Orange-colored spore pustules on leaves, petioles, or fruits	Rust	*Puccinia graminis* (Rust fungus)	V, H (Because the alternate host of cereal rusts)
BARLEY (Diseases). (See also scab under wheat diseases).			
Heads destroyed by transformation into black powdery masses			
Head with smut mass held intact by covering scales until harvest	Covered smut	*Ustilago hordei*	I, A or B
Smut mass dissipated by harvest only central axis of head left	Naked smut	*Ustilago nuda* (Smut fungi)	I, F (soak 5 hrs. then 10 min. at 127° F.)
Some kernels replaced by hard black enlarged spurs (sclerotia)	Ergot	*Claviceps purpurea* (Sac fungus)	XI, clean seed
Dark stripes between veins, shredding of leaves, sterile or stunted grain, death of plant	Stripe disease	*Helminthosporium gramineum*	I, A or F
Irregular brown blotches or spots on leaves with some netted appearance . . .	Net blotch	*H. teres*	Control not perfected
Small brown spots on leaves, no netted character	Spot blotch	*H. sativum* (Imperfect fungi)	Control not perfected
Red or black spore pustules on leaves or stems	Rusts	*Puccinia* spp. (Rust fungi)	XI, Bb; VI, Ia or d

BARLEY (Insects). See general grain and grass insects; also European grain aphis, stalk borer and other wheat insects.

BEAN (Diseases). See also Southern blight under *pepper diseases;* damping-off under *seedling diseases.*			
Brown powdery spore dots on leaflets	Rust	*Uromyces appendiculatus* (Rust fungus)	V, G
White superficial growth on leaves or stems	Powdery mildew	*Erysiphe polygoni* (Sac fungus)	III, I (dusting) III, H
Foliage showing dry, brown, papery spots which rupture and leave irregular tears. Pods and stems also affected	Blight	*Pseudomonas phaseoli* (Bacterium)	XI, A, d; I, A
Rust-colored, depressed spots on pods and young stems (Attacks leaves also). . .	"Rust" or Anthracnose	*Colletotrichum lindemuthianum* (Imperfect fungus)	XI, Ag; IX, C
Conspicuous white patches on pods; also on leaves and stems (Lima bean only) . .	Downy mildew	*Phytophthora phaseoli* (Downy mildew)	V, G; III, A (3 times)
Yellowing of foliage or rosetting of top with few or no pods; early death of plants, brown fungus threads on roots	Rhizoctonia diseases	*Corticium vagum* var. *solani* (Basidium fungus)	XI, A; VI, Ab and F
Basal portion of stem rotted, producing a cottony mold; black seed-like bodies, the sclerotia within the affected stems	Wilt	*Sclerotinia libertiana* (Sac fungus)	V, G and H; VI, F

Large brown spots on pods showing black concentric spore dots	Pod Spot	*Phoma subcircinata* (Imperfect fungus)	III, A or F
Angular brown spots on leaves causing yellowing and defoliation	Leaf spot	*Cercospora cruenta* (Imperfect fungus)	III, A or F

BEAN (Insects). See flea beetles and cutworms under *garden insects;* blister beetles under *potato insects;* pea aphis and pea moth under *pea insects;* and the smaller corn-stalk borer under *corn insects.*

Affecting stem or root.			
Bluish-green worm burrowing in stem enlargements (Lima bean)	Lima bean stem borer	*Monoptilota nubilella*	VI, Ab
White soft-bodied maggot eating young tender sprouts below ground level	Root maggot	*Pegomya fusciceps* (Fly)	III, P (Soil)
Affecting seed or pods.			
Attacking seeds only.			
Grubs within or beans showing round holes from which adults have emerged.			
Beetles brownish mottled, ⅛ inch	Bean weevil	*Acanthoscelides obtectus*	IV, Ba; VI, F
Beetles four-spotted, ⅛ in.	Four-spotted bean weevil	*Parchymerus quadrimaculatus*	IV, Ba; VI, F
Black with light markings 3-16-¼ inch (Bread or horse bean only)	Broad-bean weevil	*Bruchus rufimanus* (Beetles)	IV, Ba; VI, F
Attacking pods and seeds.			
Larvæ bore through pods and eat the growing beans (Lima beans)	Lima bean pod-borer	*Etiella zinckenella* (Moth)	XI, Bb (any climbers)
Numerous small tunnels through the seed and stem before the seedling comes above ground. Adults slender, white, ⅛-¼ inch long with 12 pairs of legs (Lima beans)	Lima bean symphylid	*Scutigerella californica* (Symphylid)	VI, F
Affecting the foliage.			
Leaf-eating beetles (larvae eat foliage also)			
Ground color yellow or red, margined with black and 4 black spots on its back, ¼ inch long	Bean leaf-beetle	*Ceratoma trifurcata* (Beetle)	III, K (field beans); III, X (string beans)
Light brown, 8 dark dots on each wing cover, ¼ inch long	Bean lady-beetle	*Epilachna corrupta* (Beetle)	Ditto
Caterpillars eating the leaves			
Yellow dotted with black, 1½ inches when mature	Bean leaf-roller	*Eudamus proteus* (Moth)	III, K
Light green, striped with darker green and fine white or cream-colored lines, 1 inch when mature	Green clover-worm	*Plathypena scabra* (Moth)	III, as for leaf beetles
Small insects sucking juices from leaves and tender shoots			
Black soft-bodied insects, closely clustered 1/10 inch long	Bean aphis	*Aphis rumicis* (Plant lice)	III, V
Foliage first yellowish mottled and then drying and browning:			
Minute spider-like insects on under side of leaves, 1/50 inch	Red spider	*Tetranychus telarius* (Mite)	III F, I (dust or atomic 1-10) or S
Minute winged insects	Bean thrips	*Heliothrips fasciatus* (Thrips)	III, F + V

BEET (Diseases)

Troubles affecting the foliage.			
Leaves showing numerous circular, ashen or brown spots, few or abundant enough to kill the entire leaf blade	Leaf spot	*Cercospora beticola* (Imperfect fungus)	I, Aa; III, A
[illegible] dark brown or black spots, 1/16 in. to 1¼ in. diameter	Leaf spot	Pseudomonas sp. (Bacterium)	Not perfected

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Leaves showing white, blister-like pustules	White rust	*Albugo bliti* (White rust fungus)	Not generally serious. V, G; VI, F
Leaves showing orange, brown or black spore dots	Rust	*Uromyces betæ* (Rust fungus)	V, I (early stage); V, O; III, A
Troubles affecting primarily the root			
Causing a dry rot (also attacking leaves and petioles,	Root rot	*Phoma betæ* (Imperfect fungus)	V, N; VI, F; IX, D
Causing a soft rot	Soft rot	*Bacterium teutlium* (Bacterium)	IX, B and D
Corky rough scabs on surface	Scab	*Actinomyces chromogenus* (Bacterium)	V, N (especially potato ground)
Irregular, tumor-like outgrowths	Gall	*Urophlyctis leproides* (Pond scum parasite)	V, H (early)
Weft of violet fungous filaments covering the root, circular areas of field generally involved	Violet rhizoctonia	*Rhizoctonia crocorum* (Sterile fungus)	See alfalfa
Brown fungous threads on root, white powdery growth on lower petioles following moist periods	Rhizoctonia disease	*Corticium vagum* var. *solani* (Basidium fungus)	V, N or VI, F; VI, HA or b

BEET (Insects). See cutworms, flea-beetles, garden web-worm, 12-spotted cucumber beetle under *garden insects;* blister beetles under *potato insects;* carrot beetle under *carrot insects;* celery leaf tier under *celery insects;* and spinach flea-beetle under *spinach insects.*

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Insects attacking the roots			
Plants undersized, sickly, lice feeding on roots	Root lice	*Pemphigus betæ Tychea brevicornis* (Aphids)	No direct means known
Larvae shiny yellowish-brown, $\frac{3}{4}$ inch long, cutting off the tap roots of young plants; often working up the stems	Sugar beet wire-worm	*Limonius californicus* (Click-beetle)	VI, Ab; VI, Ia; VI, C
Insects attacking the foliage			
Larvæ and adult beetles eating holes in leaves or destroying young plants:			
Adults pale, yellowish brown, $\frac{1}{4}$ inch	Western beet-leaf beetle	*Monoxia consputa* (Beetle)	III, A; X, Be, (early beets destroy before main crop is up
Adults dull yellowish brown, generally with two-dark longitudinal bands on each wing cover, $\frac{1}{4}$–$\frac{1}{3}$ inch	Sugar beet leaf-beetle	*Monoxia puncticollis* (Leaf beetles)	III, A; X, Be (early beets for destruction, before main crop is up)
Minute pale yellowish green active insects causing or related to "curly top"	Beet leaf-hopper	*Eutettix tenella* (Leaf-hopper)	III, F + V; VI, Ia
Leaf-eating caterpillars ,webbing up foliage as they feed			
Brown with median white-bordered, dark stripe	Sugar beet web-worm	*Loxostege sticticalis*	III, K
Dark green	Southern beet web-worm	*Pachyzancla bipunctalis* (Moths)	III, K
Producing no web, dark green and distinctly striped	Beet army worm	*Laphygma flavimaculata* (Moth)	III, K; VI, C

BLACKBERRY (Diseases)

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Trouble showing primarily on leaves:			
Small ashen-gray spots with dark border. (See also anthracnose)	Leaf spot	*Septoria rubi* (Imperfect fungus)	III, A, when severe
Under side of leaves livid red or orange in early spring, powdery shoots stunted	Orange rust	*Gymnoconia interstitialis* (Rust fungus)	V, H (roots also)
Small, pale yellow or whitish spots on under side of leaves, appearing late in season	Late rust	*Kuehneola albida* (Rust fungus)	Not prevalent enough to require treatment
Trouble affecting the fruits:			
Berries covered with a gray powdery mold	Gray mold or fruit rot	Botrytis sp. (Imperfect fungus)	Prune to avoid crowding and admit sunlight

Trouble affecting the roots or crown:			
Plants wilt and die; toadstool fruits appear around the crown	Mushroom root rot	*Armillaria mellea* (Gill fungus)	V, N or H
Trouble most evident on canes:			
Canes splitting from the formation of irregular tumors, frequently in elongated streaks.	Crown gall	*Pseudomonas tumefaciens* (Bacterium)	V, N; V, H or I
Canes showing small, pale depressed spots, sometimes dark-bordered. (Fruits may show dried drupelets or spotted leaves)	Anthracnose	*Plectodiscella veneta* (Sac fungus)	See special schedule in Chap. 32
Canes showing extended gray areas studded with minute black spore-fruits; plants wilt and die	Cane blight	Mycosphœrella sp. (Sac fungus)	V, I; III, A
BLACKBERRY (Insects). See also cane borer, cane maggot, root borer, saw fly, tree crickets and spanworm under *raspberry insects;* crown moth and leaf roller under *strawberry insects;* leaf hopper and rose curculio under *rose insects.*			
Small grubs make blotch mines in the leaves	Leaf miner	*Metallus rubi* (Saw-fly)	III, V
Hard enlargements or galls on cane inhabited by several small fleshy larvæ . . .	Pithy gall	*Diastrophus turgidus* (Fly)	V, I
Cane swollen, with spiral tunnel just beneath the bark; white grub becoming "red-necked" (thorax) beetle	Red-necked cane borer	*Agrilus ruficolis* (Beetle)	V, I (the affected canes)
BROOM CORN (See Sorghum troubles.)			
BUCKWHEAT (Diseases)			
Whitish powdery patches on under surface of leaves	False mildew, leaf blight	*Ramularia rufomaculans* (Imperfect fungus)	Rarely severe
Circular, reddish-brown spots on the leaves	Leaf spot	Ascochyta sp. (Imperfect fungus)	None necessary
CABBAGE (Diseases). See also wilt under *lettuce diseases;* downy mildew and white rust under *radish diseases;* powdery mildew under *turnip diseases;* soft rot under *carrot diseases;* and damping-off under *seedling diseases.*			
Yellowing and falling of lower leaves, retarded growth, death	Wilt or yellows	*Fusarium conglutinans* (Imperfect fungus)	V, N; XI, Bb
Plants stunted, lateral or main roots abnormally swollen	Club root or Finger-and-toe disease	*Plasmodiophora brassicæ* (Slime mold)	V, N; VI, F or Ha
Blackening of veins at edges of leaves, discoloration later extending into the stem; rotting of head, internal, dark, ill-smelling	Black rot	*Pseudomonas campestris* (Bacterium)	V, N; VI, F destroy all cruciferous weeds
CABBAGE (Insects). See also *general garden insects*, and root maggot under *radish insects.*			
Soft-bodied grayish powdery lice on leaves or young stems	The cabbage aphis	*Aphis brassicæ* (Plant lice)	III, V; V, G
Leaves shrivel and turn brown, due to work of bug (½ inch) marked with red, yellow and blue	Harlequin cabbage bug "Calico back," "Terrapin bug"	*Murgantia histrionica* (Bug)	V, G, (fall); X, Be (Kale or mustard early in spring + III, N 25 %)
Small grubs mining the leaves	Leaf miners	Scaptomyza (3 spp.) Agromyza (1 sp.) (Flies)	V, I; X, A for adults
Caterpillars or worms eating the leaves:			
Velvety green adults 1–1¼ inches, disfiguring the heads by deposits of excrement; adult the white "cabbage butterfly"	Cabbage worm	*Pontia rapæ* *Pontia protodice*	III, K or M until half grown; III, W later; V, G
Bluish, with narrow cross stripes of black, ⅝ inch long	Cross-striped cabbage worm	*Evergestia rimosalis* (Moth)	" "
Green, ⅓ inch	Diamond back moth	*Plutella maculipennis* (Moth)	" "
Green, faint whitish stripe down each side, travels with looping movement . . .	Cabbage looper	*Autographa brassicæ* (Moth)	" "

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Yellowish, five narrow stripes, webbing up the leaves	Cabbage web worm	*Hellula undalis* (Moth)	" "
Whitish grub tunneling in stalks	Cabbage curculio	*Ceutorhynchus rapæ* (Snout beetle)	III, K (seed beds) X, Be (hedge mustard and wild pepper grass)
CANTALOUPE (Diseases). See also downy mildew, powdery mildew, and leaf spots under *cucumber diseases;* wilt and anthracnose under *watermelon diseases;* Southern blight under *pepper diseases.*			
Soft rot, beginning on ground side	Soft or bacterial rot	*Bacillus melonis* (Bacterium)	III, A; turning to expose all sides to light
Leaf spots at first small, circular, brown, usually with concentric rings, dark mold in centre, enlarging and blighting the leaf	Leaf blight	*Alternaria brassicæ* (Imperfect fungus)	VI, F; XI Bb; III, A 3-6-50
Stems drying at the nodes, dry spots bearing numerous minute brown spore fruits	Wilt	*Mycosphærella citrullina* (Sac fungus)	III, A (before disease appears)
CANTALOUPE (Insects). See also flea beetles under *potato insects;* red spider under *greenhouse insects;* cucumber beetles under *cucumber insects* and squash borer, squash bug and squash lady beetle under *squash insects.*			
Numerous green yellow-legged lice ($\frac{1}{16}$ inch) on under surfaces of leaves; causing much curling and death of affected parts	Melon aphis	*Aphis gossypii* (Plant lice)	III, V or IV, B (cover with tub use 1 tablespoonful to 20 gallon tub
Whitish or greenish worm boring into the fruits. (Blossoms, leaves and stems also injured	The pickle worm	*Diaphania nitidalis* (Moth)	X, Be (early squash), V, G; VI, Ab
Yellowish worm with two light stripes down its back; eats foliage first, then attacks the fruit	Melon caterpillar	*Diaphania hyalinata* (Moth)	Ditto, and III, K or M
CARROT (Diseases). See also leaf spot under celery diseases.			
Brown fungous threads on roots; foliage yellowed or blighted	Root rot or Rhizoctonia disease	*Corticium vagum* var. *solani* (Basidium fungus)	See potato; also avoid potato ground
Root rotted, soft	Soft rot	*Bacillus carotovorus* (Bacterium)	VI, F; V, O; IX, D; also dry in sun
CARROT (Insects). See celery caterpillar, celery looper, under *celery insects;* leaf tier under *greenhouse insects* and also *general garden insects.*			
Leaves red or rusty looking, roots tunneled by small brown maggots	Carrot rust fly	*Psila rosæ* (Fly)	VI, F; X, Dg; VI, Ib
Roots eaten by beetle, black above, reddish beneath (½ inch)	Carrot beetle	*Ligyrus gibbosus* (Beetle)	V, G; VI, Ab
CAULIFLOWER (Diseases). (See also *cabbage diseases.*)			
Surface of head showing numerous projecting points instead of being solid, becoming more loose with growth	Ricing	Rain following long drought	VII, B by irrigation or cultivation
Brown, discolored patches (Dry rot) on surface of head	Blossom-end rot	Unfavorable soil relation not definitely worked out	VII, B
CAULIFLOWER (Insects). (See *cabbage insects.*)			
CEDAR, RED (Diseases)			
Twigs with chocolate-brown galls which become orange-colored and gelatinous during warm spring rains	Cedar apples (stage of apple rust)	Gymnosporangium spp. (Rust fungus)	Do not use for orchard wind breaks
Wood full of elongated pockets of brown, brittle wood, bracket fruits produced	Peckiness or Red rot	*Polyporus carneus* (Pore fungus)	V, H old trees; V, J
Wood brown between long holes in the heart wood, holes filled with white or reddish mold	White rot	*Polyporus juniperinus* (Pore fungus)	V, H old trees; V, J

CEDAR, GIANT MOUNTAIN (Diseases).			
Groups of scale leaves brown and dead, showing minute black spore fruits	Blight	*Keithia thujina* (Sac fungus)	None practical for forest conditions
CEDAR, INCENSE (Diseases)			
"Witches' brooms" from which gelatinous horns are produced (stage of an apple, pear and quince rust on Pacific Coast)	Witches' broom	*Gymnosporangium blasdaleanum* (Rust fungus)	None necessary for cedar; see alternate hosts
CEDAR (Insects). (See insects of *coniferous trees.*)			
CELERY (Diseases). (See damping-off under *seedling diseases.*)			
Leaves and petioles spotted:			
Spots angular, becoming light ashen gray	Early blight	*Cercospora apii* (Imperfect fungus)	III, A (Early) D later; V, G
Spot angular, spreading, showing numerous black spore fruits on all diseased parts	Late blight	*Septoria petroselini* (Imperfect fungus)	VII, C; III A or D in field; Dip in III D before storage
Spots not angular, dull brown	Leaf spot	*Phyllosticta apii* (Imperfect fungus)	Controlled by blight treatments
Leaf stalks rotted:			
A soft, light brown rot of the central bud	Centre blight or soft rot	Bacteria	See soft rot of carrot
Rotting parts producing a white cottony mold	Storage rot	*Sclerotinia libertiana* (Sac fungus)	IX, D and E
Plants producing flower stalks the first season	Annualism	Unfavorable temperature and water relations	VII, B constant supply
CELERY (Insects). See also carrot beetle and carrot rust fly under *carrot insects;* and *general garden insects.*			
Bright green or yellow caterpillars, cross-banded with velvet black; eat the foliage.	Celery caterpillar	*Papilio polyxenes* (Swallow-tail butterfly)	III, K; or if few jar off and crush
Whitish caterpillars with green stripe down the back, fold over or tie together leaves, feeding within	Celery leaf-tier	*Phlyctænia ferrugalis* (Moth)	III, K (early) X, Fa later
Green looping caterpillar feeding on the foliage	Celery looper	*Plusia simplex* (Moth)	III, Ma (with lime) Wash off before using
CHARD. (See beet diseases and insects.)			
CHERRY (Diseases). See also black knot and brown rot under *plum diseases;* crown gall, hairy root and root rots under *apple diseases;* rust, scab, Cercospora shot-hole under *peach diseases.*			
Leaves spotted or covered with mildew:			
Small purple or brown spots, either with or without perforation; frequently causing more or less yellowing and defoliation	Shot-hole or yellows	*Coccomyces hiemalis* (Sac fungus)	III, Ac, F (1–40), or G 10-10-50. One month after blooming; just after picking
Leaves more or less curled, light powdery early in season, later with many minute black spore-fruits	Powdery mildew	*Podosphæra oxyacanthæ* (Sac fungus)	III, Ac or I at intervals according to severity
Brown, or brown purple-bordered spots, with or without perforation, but larger than in yellows. Fruit also attacked, showing several sunken brown spots	California blight	*Coryneum beijerinckii* (Imperfect fungus)	See peach for treatment
Affected parts showing witches' broom, i. e., an abnormal number of closely aggregated branches; leaves of broom frequently reddish and curled	Leaf curl or witches' broom	*Exoascus cerasi* (Sac fungus)	V, I the witches' brooms
Exudation of gum very evident from trunk or branches; large or small cankers on various parts; blighting of buds and fruit spurs, or general attack blighting large parts or killing entire tree	Bacterial gummosis	*Pseudomonas cerasus* (Bacterium)	V, I and J (protection) XI, Bb (Mazzard and limb graft)
Cankers not generally evident, gumming general or only localized. (Difficult to distinguish from bacterial gummosis). Death of branches or whole tree (not infectious)	Non-parasitic gummosis or die-back	Unfavorable environment	VI, J; VIII, B, D, G

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Fruit falls when small and only partly developed	Fruit drop	Unfavorable environment. Lack of cross pollination, etc.	Remove cause; introduce pollinizers
CHERRY (Insects). See also bud-moth, leaf-rollers, leaf-crumpler, canker-worm, California tussock-moth, oriental moth, forest tent-caterpillar, red-humped caterpillar, climbing cutworms, buffalo tree-hopper, San José scale, Putnam's scale, twig-girdler, flee-beetles, clover mites under *apple insects;* pear slug under *pear diseases;* plum curculio, web-spinning saw-fly, European fruit-tree scale under *plum diseases;* peach-tree borer, Pacific peach-tree borer, lesser peach-tree borer, fruit bark-beetle, white peach scale, green June beetle under *peach insects;* walnut scale under *currant insects;* and imbricated snout-beetle under *strawberry insects.*			
Yellowish-white maggot in the pulp; little external evidence of its presence. (Plum curculio makes conspicuous egg punctures)	"Wormy cherries" Cherry fruit flies	Rhagoletis spp. (Fly)	III, K 5–100 + 3 gallons molasses early in June
Maggot eating the kernel of the pit in young cherries or the pulp in older cherries	Cherry fruit saw fly	*Hoplocampa cookei* (Fly)	Control not perfected; VI, B if practical
Large pointed silken nests enclosing leaves and twigs and a colony of lemon-yellow caterpillars ([illegible] inch when full grown)	Cherry tree Tortrix	*Archips cerasivorana* (Moth)	V, I
Leaves and young stems covered with numerous black soft-bodied lice, leaves soon much curled	The cherry plant louse	*Myzus cerasi* (Aphid)	III, V; X, Ib for tips of nursery stock
Scales on twigs, the nearly central spot reddish orange. (See other scales noted above)	The cherry scale	*Aspidotus forbesi* (Scale)	III, (See San José scale under apple)
CITRUS FRUITS (Diseases). (See damping-off of *seedlings.*)			
Diseases in which a rotting of the fruit is the most evident character			
Blue-green mold on rotting spots	Blue or green mold	*Penicillium italicum; P. digitatum*	IX, B, F
Rot starting at stem-end, rotted area becoming coffee-colored, advancing most rapidly along the fibrous core	Stem-end-rot	*Phomopsis citri*	Control scale insects IX, B, D; V, G (including fallen fruit)
Circular sunken spots, followed by soft rot. (Mainly on grape fruit)	Anthracnose	*Colletotrichum gloeosporioides*	III, D if severe
Fruits of navel orange with black decayed centre	Black rot	*Alternaria citri*	Not generally serious. V, I (diseased fruit)
Rot starting at the stem end, but becoming darker than the stem-end rot	Diplodia rot	*Diplodia natalensis* (Imperfect fungi)	V, I; IX, B
Fruits showing brown rotted tissues; no visible growth of mold in the open	Brown rot	*Pythiacystis citrophthora* (Water mold)	III; straw under trees; IX, G (Copper sulphate or potassium permanganate)
Fruits softened and covered with a white mold which later forms dark seed-like bodies (sclerotia)	Cottony rot	*Sclerotinia libertiana* (Sac fungus)	IX, G (copper sulphate 1-50 per cent)
Fruits soften and develop a mouse-gray, powdery mold on the surface	Gray mold	*Botrytis cinerea* (Imperfect fungus)	IX, B, D; V, I (affected fruit)
Fruits showing black sunken spots	Black pit	*Pseudomonas citriputeale* (Bacterium)	Not serious
Fruits (lemon) showing irregular sunken spots, after sometime in the curing house	Peteca	Unknown	None known
Large irregular rusty brown spots which become sunken and then dark red or black	Red rot	Unknown	None known
Green spots on the yellow rind	Green spot	Action of lemon oil or rind	IX, B
Diseases affecting twigs, leaves and sometimes the fruits (except rots)			
Circular, dead spots on leaves, twigs and fruit and irregular cankers with light bordering membrane on the older branches	Canker	*Pseudomonas citri* (Bacterium)	V, H (Burning)

Small raised swellings with a wax-like appearance, varying from yellow to brown, more rarely black	Melanose	*Phomopsis citri* (Imperfect fungus)	V, I (all dead wood); III, A
Rough corky projections on leaves twigs and fruit	Scab or verrucosis	*Cladosporium citri* (Imperfect fungus)	V, C (sour orange); III, D or A 3-3-50
Young tender shoots and leaves wither and blight (lime trees only)	Wither tip of limes	*Gloeosporium limetticolum* (Imperfect fungus)	III, D
Slow death of twigs and branches, fruits sometimes "tear stained"	Wither tip (varieties other than limes)	*Colletotrichum gloesporioides* + other fungi and adverse conditions	V, F, G, I; or III, D if very serious
Black sooty mold covering the affected parts; rubs off easily	Sooty mold	*Meliola camelliae* (Sac fungus)	See white flies. Control these insects
Dying back of branches with gum pockets, dark warts, and multiple buds; irregular markings on the fruits with gum formation at the centre	Exantheme or die-back	Malnutrition	Correction must depend on cause
Yellow areas on each side of leaf between the lateral veins	Mottled leaf or frenching	Malnutrition	VI, Gb; VII, B (Mulched basin system)
Leaves uniformly yellowed	Chlorosis	Malnutrition	Seek cause and modify condition
Leaves wilt and drop off or remain hanging; water sprouts produced in abundance to later sicken and die	Blight	Unknown	V, H

Diseases in which gum formation is a marked character

Bark more or less roughened or scaly:			
Outer bark dies and is pushed off, affected areas extending to surround branch or trunk, and bark finally killed down to the wood	Psorosis or California scaly bark		V, I or scrape off diseased bark; apply fungicide
Rusty, round or oval, raised spots on young branches; may increase in number till they join and form large patches of reddish brown, scaly bark; brown sunken spots on fruit	Florida scaly bark or nailhead rust	*Cladosporium herbarum* var. *citricolum* + other factors	V, I (pruning) III, A
Localized dark cankers on limbs, or twigs killed back. (See also fruit rots)	Diplodia gumming	*Diplodia natalensis* (Imperfect fungus)	V, I (pruning)
General or localized killing of bark at the crown:			
Roots rotted, brown fungous strands on roots, mushroom odor; often toadstool fruits form near crown	Mushroom root-rot	*Armillaria mellea* (Basidium fungus)	X, Cc (deep trench around affected tree)
Bark killed through to wood at centre of affected area, surrounded by wide zone in which outer bark only is killed. (See fruit rot)	Botrytis gummosis	*Botrytis cinerea* (Imperfect fungus)	V, K and J
Inner and outer bark about equally affected and killed down to the wood. (See fruit rots also)	Pythiacystis gummosis	*Pythiacystis citrophthora* (Water mold)	V, KandJ (Protection). Remove dirt around crown
Very similar to brown rot gummosis, rarely extending so far above the crown; bark and wood become rotten and often of a fetid odor	Mal di gomma or foot rot	Unfavorable environmental conditions	XI, C (sour orange roots) also V, K and J

CITRUS FRUITS (Insects). See also Western 12-spotted cucumber beetle under *cucumber insects;* the cotton stainer under *cotton insects,* leaf-cutting ants and others under *general tree insects.*

Insects minute, or microscopic and generally overlooked by grower

Tissues of bark, leaves or fruit silvery (Lemon) Tissues russeted (Orange)	Silver mite of lemon. Rust mite of orange	*Eriophyes oleivorus* (Mite)	See citrus red spider
Leaves whitish mottled, fruits russety or scabby; adult insects yellowish brown to dark brown	Greenhouse thrips	*Heliothrips haemorrhoidalis*	See citrus thrips
Leaves thickened or crinkled or fruit scarred with regular or irregular circles around stem or blossom ends; adult insects orange-yellow	Citrus thrips	*Scirtothrips citri* (Thrips)	III, F (1-80); III, V (1-1800)
Leaves whitish-mottled (also fruits).			
Adults cardinal red, size of pin point	Citrus red spider	*Tetranychus mytilaspidis* (Mite)	III, F (2½ per cent. solution + 4 gal. flour paste to 100 gal.)
Adults red with yellowish tinge and sometimes with 2 dark spots	Two-spotted mite	*Tetranychus telarius* (Mite)	Ditto; also III, I (atomic sulphur 5-50)

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Insects evident, never microscopic in size			
Circular or elongated, flat or convex, variously colored insects, generally closely appressed to leaves, twigs or fruit (Scale insects). Adults generally sedentary and closely appressed to substratum	Scale insects	20 or more species	III, F, N, O, P or Q (winter); IV, Dc or d X, G (fungous parasites)
Adults (females) more at will (1/8-3/8 inches); covered with thick white waxy secretion	Mealy bugs	*Pseudococcus* spp. (Mealy bugs)	III, P between October and March
Small white-winged active adult-insects (1-10 inch); young inactive on under side of leaves, causing yellowing and defoliation	White flies	*Aleyrodes* spp. (White flies)	IV, Dc or d
Small soft-bodied green or black insects on leaves and succulent twigs (aphids or lice). Dull black or brown, 1-16 inch	Black citrus aphis	*Toxoptera aurantiae*	III, N, O or Q for winter; III, V for summer Same for all aphids
Dull black or brown, 1-12 inch; legs white	Bur clover aphis	*Aphis medicaginis*	....
Dark, varying from yellowish to dark green, brown or black	Melon aphis	*Aphis gossypii*	....
Yellowish to rich green	Green peach aphis	*Rhopalosiphum persicae*	....
Pea green in color	Green citrus aphis	*Macrosiphum citrifolii* (Aphids or Plant lice)	....
White or dusky larvae (1/4-3/4 inch) eating leaves, twigs and fruit and burrowing through the rind, causing premature fall or decay	Orange tortrix	*Tortrix citrana* (Moth)	III, K if it becomes abundant
Gray to dark brown, wingless beetles, (3/8-1/2 inch) eating buds, tender shoots or foliage	Fuller's rose beetle	*Pantomorus fulleri*	X, Ca (cotton or tanglefoot)

CLOVER (Diseases). See also dodders, wilt and leaf spot under *alfalfa diseases;* broom-rape under *tobacco diseases.*

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Brown, sunken, elongated spots on stems which split at the lesion and break off easily; foliage also spotted	Anthracnose	*Colletotrichum trifolii* *Gloeosporium caulivorum* (Imperfect fungi)	IX, A; XI, Bb "
Sooty or black specks on the under side of the leaves	Sooty or black spot	*Phyllachora trifolii*	None. Rarely severe
Brown, granular spore-dots on the leaves	Rust	*Uromyces* spp.	IX, A
Leaves white powdery, later with numerous black spore-fruits	Powdery mildew	*Erysiphe polygoni*	IX, A if disease is abundant

CLOVER (Insects). See also spotted blister beetle and flea beetles under *potato insects;* leaf weevil, semi-looper, leaf caterpillar and crane fly under *alfalfa insects;* northern grass worm, army worms and grasshoppers under *general grain insects.*

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Attacking and injuring the roots:			
Tap root with circular or elongated, darkened, corroded or eaten areas	Clover root weevil	*Sitones flavescens* (Snout beetle)	VI, F, Bc
Tap root tunneled by small brown beetle (1/8 inch) or its larva	Clover root borer	*Hylastes obscurus* (Beetle)	VI, F (Plow as soon as clover is cut)
Small grub boring in the pith of stem. Adult beetle (1/4 inch) with red head and thorax and bluish-black wing covers	Clover stem borer	*Languria mozardi* (Beetle)	IX, A if abundant
Attacking and eating or injuring the leaves:			
Eaten from the margin in regular fashion (curved or semicircular pieces removed).	Clover leaf weevil	*Phytonomus punctatus* (Snout beetle)	Controlled by natural enemies
Holes eaten through the leaves, and at blooming time the inner parts of heads destroyed by a tiny grub	Lesser clover leaf weevil	*Phytonomus nigrirostris* (Snout beetle)	V, G; IX, A
Holes eaten through the leaves or irregular marginal attacks; larvæ working in softer parts of the stems	Flavescent clover weevil	*Sitones flavescens* (Snout beetle)	V, G; IX, A
Leaves become yellow mottled or yellow and then dry up and fall off; red spiders on under surface	The clover mite	*Bryobia pratensis* (Mite)	III, N, O or Q for fruit trees in winter
Pinkish, yellowish or greenish soft-bodied insects sucking the juices from stems and leaves	Aphids or lice	Several species	IX, A

Affecting the seed:			
Minute maggots prevent normal development of flowers of the heads and feed on the developing seed	The flower or seed midge	*Cecidomyia leguminicola* (Fly)	Pasture let these late seed crop develop; or IX, A
Heads appear normal, but many empty hulls due to work of a minute grub	Clover seed chalcid fly	*Bruchophagus funebris* (Fly)	IX, A
Greenish white larvæ (¼ inch) destroy seed by eating through the florets at the base	Clover seed caterpillar	*Grapholitha interstinctana* (Moth)	See seed midge
Dark brown caterpillars eating the hay in mow or stack	Clover hay worm	*Pyralis costalis* (Moth)	IX, H (use first year); Do not stack on old hay

COLLARDS. (See *cabbage diseases* and *insects.*)

CONIFEROUS TREES (General Diseases)

Seedlings dying in the seed-bed	Damping-off	Various fungi	II, C, b
Adult trees affected by rot of either sap wood or heart wood	Heart rot or sap rot	Various basidium fungi	General forest sanitation and utilization
Adult trees affected by rot of the root system	Root rot	Various basidium fungi	
Yellowish or yellowish-green scaly shoots growing from witches' brooms or stem enlargements	Mistletoe	Razoumofskya spp.	V, H (and "utilization instead of destruction)

CONIFEROUS TREES (General Insects). Various scale insects, the gray leaf beetle, shot-hole borers and other wood or bark borers.

CORN (Diseases)

Tumors on leaves, stalk, ears or tassel covered with light membrane when young, bursting later to expose the black powdery mass	Smut	*Ustilago zeae* (Smut fungus)	VI, F; V, O
Ears showing a dry rot:			
Whitish mold; dark spore-fruits between kernels, evident on broken end of ear.	Diplodia rot	*Diplodia zeae*	VI, F; G and I
Whitish or pinkish mold between kernels; no spore fruits	Fusarium rot	Fusarium spp.	VI, F; V, G and I
No mold present, kernels darkened and rotting.	Bacterial rot	Various bacteria	Ditto
Brown granular spore dots on the leaves	Rust	*Puccinia sorghi* (Rust fungus)	Not serious
Elongated areas of leaves brown and dead; a thin olive-brown mold present	Leaf blight	*Helminthosporium turcicum* (Imperfect fungus)	VI, I a
Plants generally dwarfed, yellowish brown or reddish patches on the leaf sheaths	Blight	*Bacillus sorghi* (Bacterium)	None perfected
Plants wilt and dry up as if from drought (Sweet corn)	Wilt	*Pseudomonas stewartii* (Bacterium)	V, O; XI, A; XI, Bb

CORN (Insects). See also wire-worms, grasshoppers, army worms, and spring grain aphis, grain weevils, beetles, and moths under *general grain insects;* chinch bug under *wheat insects;* stalk-borer and blister beetles under *tomato insects;* garden web-worm under *general garden insects;* root-maggot under *bean insects;* carrot beetle under *carrot insects;* sugar-cane beetle under *sugar cane insects.*

Insects attacking and feeding on the roots:			
Plants dwarfed, leaves yellowish or reddish.			
Bluish-green soft-bodied insects with white waxy bloom massed upon the roots.	Corn-root louse	*Aphis maidi-radicis*	VI, F; VI Aa; X, Dc
Whitish soft-bodied insects with black head and markings, massed on the roots	Grass root louse	*Schizoneura panicola* (Aphids)	VI, F; VI, Aa; avoid sod crops
Plants killed, dwarfed or deformed:			
Larvæ feeding in base of stalk; yellowish white to pink, reddish or brown with tubercles bearing hair tufts. (½-¾ inch)	Corn-root web-worm	*Crambus caliginosellus* (Moth)	VI, Aa + harrowing; avoid sod crop
Larvæ feeding on roots,—eat small ones and burrow in larger ones; adult worm white, with brown head (½ inch)			
Adult beetles, greenish or yellowish green ¼ in. long	Western corn-root worm	*Diabrotica longicornis*	V, F (Never injurious after wheat, rye or barley)
Adult beetles yellowish-green with 12 black spots on wing covers	12-spotted cucumber beetle or southern corn-root worm	*Diabrotica duodecimpunctata* (Beetles)	VI, Ib + Kb (double the amount) III, K for foliage protection

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
CORN (Insects)			
Insects attacking and feeding on the stalks (See also cut worms):			
Burrowing in the stalks; small thick-set larvæ or dark snout beetles	Bill bugs	Sphenophorus spp. (Snout beetles)	V, M; avoid recently drained land
Burrowing in the stalks:			
Worms whitish, marked with brown, ¾ inch	Larger cornstalk borer	*Diatræa zeacolella* (Moth)	V, I (old stalks in the fall); VI, F; VI, Aa
Worms light green, back with 9 fine reddish lines	Smaller cornstalk borer	*Elasmopalpus lignosellus* (Moth)	" "
Insects feeding on the ears; worms yellowish to brownish with longitudinal gray and white stripes (1½–2 inches when mature)	Corn ear-worm	*Heliothis armiger* (Moth)	VI, Aa; VI, Ia
Bluish green plant lice feeding on young leaves and tassels	Corn leaf aphis	*Aphis maidis* (Aphid)	None devised
Small beetles eating out the hearts of sprouting kernels	Slender seed-corn ground beetle	*Clivina impressifrons* (Beetle)	VII, F; VI, Ib
Small whitish or yellowish maggots (¼ inch) working in sprouting kernels; prevent growth or cause stunted sickly plants	Seed-corn maggot	*Phorbia fuscips* (Fly)	VI, Ab
COTTON (Diseases)			
Plants wilt and die either suddenly or following more or less yellowing of the leaves:			
Stem or leaf stalks show darkened veins or bundles in section	Wilt	*Fusarium vasinfectum* (Imperfect fungus)	VI, F; V, H. (By pulling and burning) XI, Bb
No bundle browning, weft of brown fungous threads on tap root, root rotted	Texas root rot	*Ozonium omnivorum* (Sterile fungus)	VI, Ab; VI, F
Ulcer-like wound on stem near ground level, discoloration of leaves; plant may recover but many seedlings die	Sore shin	Rhizoctonia sp. (Sterile fungus)	VIII, D; harrow to dry out soil
General discoloration of the foliage:			
Yellow spotted, or having a checkered appearance; spots later turn brown and are frequently covered with a dark mold	Mosaic, yellow leaf blight or black rust	Non-parasitic Unfavorable environment	VI, H (Kainit)
Red coloration toward the end of season.	Red leaf blight	Non-parasitic Poor soil	VI, Hb or VI, F (Some legume)
Leaves spotted:			
Watery or brown angular spots	Angular leaf spot	*Bacterium malvacearum* (Bacterium)	None known
Spots light yellow above, frost-like below	Frosty mildew	*Ramularia areola* (Imperfect fungus)	None practised. Disease not serious
Spots circular, brown or gray with purple borders	Leaf blight or spot	*Mycosphærella gossypina* (Sac fungus)	" "
Orange-colored cups on the under side of yellow bordered spots	Rust	*Aecidium gossypii* (Rust fungus)	" "
Trouble affecting the bolls:			
Dark sunken ulcers with watery borders, causing blight or deformity	Anthracnose	*Glomerella gossypii* (Sac fungus)	XI, A; XI, Bb; VI, F
Rot invading and destroying the boll, entirely or in part	Boll rot	Bacterial	None known
Dropping of the "squares" before maturity	Shedding	Unfavorable soil or climatic conditions	Depends on cause

COTTON (Insects). See also cut-worms, grasshoppers, flea beetles, etc., under *grain and garden insects;* oblique banded leaf roller under *apple insects*, bean thrips under *bean insects;* citrus mealy bug, two-spotted mite under *citrus insects.*

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Insects attacking and eating the foliage:			
Beetles (⅛–3/16 inch) metallic bronze below, gray above	Small elongated leaf beetle	*Myochrous longulus* (Beetle)	III, K or M if necessary

Caterpillar (1½ inch) green with dark spots and striped with black when mature	The cotton worm	*Aletia xylina* (Moth)	III, Ma; VI, F
Maggots working in mines within the leaves	Serpentine leaf miner	*Agromyza pusilla* (Fly)	VI, Aa and C
Small, soft-bodied, greenish insects sucking sap from under side of leaf	Cotton louse	*Aphis gossypii* (Aphid)	III, V or R; V, H (the first infected)
Minute reddish mites on under surface; leaves yellow spotted or brown and dead	Red spider	*Tetranychus telarius* (Mite)	V, H (first ones) III, I (dust) or III, G
Insects attacking and injuring the bolls:			
Worms (1½–2 inches when mature) yellowish to yellowish brown, and spotted, striped or plain	Boll worm (See corn ear worm)	*Heliothis armiger* (Moth)	X, Bc (corn and cotton alternately; 5 acres for each 100 of cotton)
Small fleshy grubs feeding within the squares and bolls; adult a grayish beetle (¼ inch)	Mexican cotton-boll weevil	*Anthonomus grandis* (Snout beetle)	V, H (without waiting for the top crop), + VI, Aa XI, Ba (early-maturing)
A short, thick, green caterpillar eats holes into the squares	Cotton-square borer	*Uranotes melinus* (Butterfly)	III, K (before bolls are entered)
Parts shriveled, some or all seeds aborted, or lint stained by work of a bug	Cotton stainer	*Dysdercus suturellus* (Bug) (Several other bugs cause similar effect)	VI, I; V, G (burn old stalks and rubbish early)
Small active insects puncture bolls in latter part of season but cause little injury	Cotton sharpshooters	Leaf hoppers, various species	None necessary
COWPEA (Diseases)			
Discoloration, wilting and dying of plants; veins of stem brown in section	Wilt	*Fusarium vasinfectum* (Imperfect fungus)	See cotton wilt; XI, Bb (the iron)
Foliage spotted:			
White circular or diffuse spots enlarging to cover the leaf	Powdery mildew	*Erysiphe polygoni* (Sac fungus)	None generally necessary for the 3 leaf diseases
Leaf spots angular, gray to purplish below	Angular leaf spot	*Cercospora cruenta*	
Leaf spots circular, shiny white with minute black spore fruits	Leaf spot	*Amerosporium oeconomicum* (Imperfect fungi)	Harvest early if severe
COWPEA (Insects). (See also *bean and pea insects.*)			
Small grub working in growing seeds; adult beetle bronze black (⅛ inch)	Cowpea curculio	*Chalcodermus æneus* (Snout beetle)	VI, F
Seed in storage showing grubs or adult beetles working within; or their deserted holes	Cowpea weevil	*Pachymerus chinensis*	VI, F; IV, Ba, XI, A
CRABAPPLE. (See *diseases and insects of apples.*)			
CRANBERRY (Diseases)			
Berries rotting, soft and brown or dry and almost black; minute black spore-fruits may show on leaves or stem. The 4 rots can only be distinguished by microscopic examination	Scald or blast	*Guignardia vaccinii* (Sac fungus)	III, A (6-6-50 + 4 lbs. resin fish-oil soap) 3 to 5 applications
	Rot	*Acanthorhynchus vaccinii* *Fusicoccum putrefaciens* (Imperfect fungus)	
	Anthracnose	*Glomerella rufomaculans* (Sac fungus)	
Berries rotted, with cotton-like growth within; shoots withered earlier in the season	Sclerotinia disease	*Sclerotinia oxycocci* (Sac fungus)	V, I (diseased fruit)
Normally dormant buds produce short shoots with enlarged leaves of light rose or pink color	False blossom	Non-parasitic	V, H (Scalp and replant if serious) XI, A. Improve conditions by pruning, drainage and fertilizing

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Small red galls ($\frac{1}{32}$ inch) on leaves, stems, flowers or fruit	Gall	*Synchytrium vaccinii* (Pondscum parasite)	V, M (for infected areas)
Leaves and shoots thickened and rose-colored	Hypertrophy	*Exobasidium oxycocci* (Basidium fungus)	None known
CRANBERRY (Insects)			
Worms attacking leaves, stems and berries:			
Black-headed, dark green or brown larva ($\frac{1}{2}$ inch) webs up tips, skeletonizes leaves and burrows in developing fruits	Fire worm	*Eudemis vacciniana* (Moth)	III, K (6 or 7-50) VII, B (flood, when pupae are numerous, for 3 days)
Yellow-headed, yellowish-green larva ($\frac{1}{2}$ inch) of same habits	Yellow-headed cranberry worm	*Alceris minuta* (Moth)	III, K (5-50) VII, B (hold water late as possible)
Worms eating the foliage principally:			
Mottled, pale yellowish to brown (1 inch)	Cranberry span worm	*Cleora pampinaria* (Moth)	III, K (6-50)
Pale green with fine whitish longitudinal lines (under 1 inch); eating leaves and buds	Cranberry span worm	*Cymatophora sulphurea* (Moth)	"
Light green to velvety brown, striped with narrow yellowish lines (nearly 2 inches when mature)	False army worm	*Colocampa nupera* (Moth)	III, K (2 or 3-50) when worms are young
Sooty gray caterpillar ($\frac{3}{4}$ inch) girdling the stems below the soil litter; girdled vines die and turn brown	Cranberry girdler	*Crambus hortuellus* (Moth)	VII, B (flood for 7 to 10 days after picking;) or V, M (gasoline torch)
Insects attacking the fruit only:			
Pale green caterpillar ($\frac{3}{8}$ inch) eats out pulp and seeds	Cranberry fruit worm	*Mineola vaccinii* (Moth)	VII, B as for girdler; V, I (Infested berries)
Berries injured by seed-eating katydid; adult green broad-winged ($1\frac{1}{2}$ inch)	Cranberry katydid	*Scudderia texensis* (Katydid)	VI, E (Grasses)
Terminal buds deformed into a gall-like growth; several yellowish or orange-red maggots working within ($\frac{1}{16}$ inch)	Cranberry gall fly	*Cecidomyia oxycoccana* (Fly)	Not serious nor controlled by III, K or flooding
Minute active insects ($\frac{1}{8}$–$\frac{1}{16}$ inch) feed on vines and leaves causing them to turn brown	Cranberry fulgorid	*Phylloscelis atra* (Fulgorid)	III, V (1-800)
CUCUMBER (Diseases). See also wilt and anthracnose under *watermelon diseases.*			
Stem rotting and covered with a cottony mold; black bodies (sclerotia) in the mold or within the stems	Stem rot or mold	*Sclerotinia libertiana* (Sac fungus)	V, H (before sclerotia form); II, B greenhouses
Disease most evident on the fruit:			
Spots $\frac{1}{2}$ inch diameter, gray, slightly sunken, velvety and coalescing into irregular patches	Fruit spot	*Cladosporium cucumerinum* (Imperfect fungus)	See downy mildew
Fruits yellow mottled at first later pale and smooth, or with marked protuberances; leaves also mottled and wrinkled	Mosaic or white pickle	Non-parasitic	Control aphids
Disease most evident on foliage:			
Brown or light-colored spots.			
Distinctly angular, no fungus evident	Angular leaf spot	Bacteria	I, A; XI, A; V, N
Distinctly angular, spore-tufts produced	Leaf spot	*Cercospora cucurbitae*	III, A
Spore-fruits in spot, dark	Leaf spot	*Phyllosticta cucurbitacearum* (Imperfect fungi)	III, A
White powdery coating	Powdery mildew	*Erysiphe polygoni*	Not serious in open. III, I under glass
Spots from above yellowish, angular, spreading to include entire leaf; in moist weather white spore threads and purple tinged spores on lower surface	Downy mildew	*Pseudoperonospora cubensis* (Downy mildew)	III, A (3-6-50) when vines begin to run; 4-4-50 at later intervals

CUCUMBER (Insects). See also melon aphis, pickle worm, and melon caterpillar under *cantaloupe insects;* flea-beetle under *potato insects;* squash borer, squash bug and squash lady beetle under *squash insects;* and red spider under *greenhouse insects.*

Yellow and black striped beetles ($\frac{1}{3}$ inch long) eat tender leaves and young stems . .	Striped cucumber beetles	*Diabrotica vittata*	III, K; or III, X (air-slaked lime + sulphur
Yellow and black spotted beetles ($\frac{1}{4}$ to $\frac{1}{3}$ inch) eat tender leaves and young stems . .	Spotted cucumber beetle	*Diabrotica trivittata* Diabrotica spp. (3)	" "

CURRANT (Diseases). See also powdery mildew under *gooseberry diseases.*

Trouble most evident on the foliage:			
Circular or irregular spots, $\frac{1}{4}$ inch or more in diameter, centre brown or gray . . .	Leaf spots	*Septoria ribis, Cercospora angulata* (Imperfect fungi)	III, A or F
Small, dark-brown spots with much yellowing and defoliation; small black spots also on fruit)	Anthracnose	*Pseudopeziza ribis* (Sac fungus)	III, A or F. Just as leaves are expanding and later
Orange-colored powdery spots on the lower surfaces of the leaves (stage of blister rust of pine).	Rust	*Cronartium ribicola* (Rust fungus)	Important in relation to white pine. See pine
Troubles affecting the canes:			
Affected branches with black warty thickenings	Black knot	*Plowrightia ribesia* (Sac fungus)	V, I
Young shoots or entire canes killed, wilting at various times and conspicuous by the dead brown leaves	Wilt	*Botryosphæria ribis* (Sac fungus)	V, I (Diseased canes)

CURRANT (Insects). See also green fruit worms, fruit-tree leaf-rollers, climbing cutworms, San José scale, oyster-shell scale, Putnam's scale leaf-hopper, flat-headed apple-tree borer, and flea-beetles under *apple insects;* European pear scale, European fruit-tree scale, European fruit Lecanium under *plum insects;* cherry scale under *cherry insects;* red spider under *raspberry insects* and imbricated snout beetle under *strawberry insects.*

Insects attacking the stems or canes:			
Whitish larvæ ($\frac{1}{2}$ inch) with brownish head and legs, boring in pith	Imported currant borer	*Sesia tipuliformis* (Clear-winged moth)	V, I (before June 1)
Terminal portion girdled; later dies and drops off	Currant stem girdler	*Janus integer* (Sawfly)	V, I (8 inches below the girdle)
Canes covered with pale grayish brown scales ($\frac{1}{8}$ inch) with reddish orange papilla one side of centre.	Walnut scale	*Aspidotus juglans-regiae*	See San José scale under apple
Insects attacking the foliage:			
Worms eating the leaves.			
Larvæ feed first in colonies, later scattered; first whitish, then green with black spots; then uniform green, tinged with yellow ($\frac{3}{4}$ inch)	Imported currant worm	*Pteronus ribesii* (Saw fly)	III, K (2-50) or III, W with maturing of fruit
Larvæ uniform light green with blackish heads	Green currant worm	*Gymnonychus appendiculatus* (Sawfly)	" "
Measuring worms, whitish with yellow stripes on the back and sides (one inch or less)	Gooseberry span worms	*Cymatophora ribearia* (Moth)	III, K (2-50) when young; X, Fa when old
Measuring worms, seagreen to brownish-gray or brownish-black (nearly 2 inches when mature)	Pepper and salt currant moth	*Lycia cognataria* (Moth)	Same as imported currant worm
Bugs sucking the leaf juices; vermilion red when young, adults bright orange-yellow with 4 black stripes; leaves become spotted or turn brown, curl up and die . .	Four-lined leaf-bug	*Paecilocapsus lineatus* (Bug)	III, N when in nymph stage; V, I (twigs with eggs)
Leaves curled, discolored and distorted by mottled green lice on their under surfaces	Currant plant louse	*Myzus ribis* (Aphid)	III, N or V when eggs hatch with nozzle bent up
Insects attacking the fruit. Small grub burrowing in pulp causes premature discoloration, fall or decay:			
Adult flies pale yellowish, about as large as house fly.	Yellow currant fruit-fly	*Epochra canadensis* (Fly)	VI, Ba
Adult flies black with 4 yellow stripes on the thorax	Dark currant fruit-fly	*Rhagoletis ribicola* (Fly)	VI, Ba

DEWBERRY (Diseases). See also leaf spot, cane blight, and orange rust under *blackberry diseases.*

Witches' brooms in place of normal shoots; flowers with increased and thickened parts	Double blossom	*Fusarium rubi* (Imperfect fungus)	V, I (the deformed buds)

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
EGGPLANT (Diseases)			
Rotting of the fruit an evident character:			
Tan blotches becoming soft and producing a gray powdery mold	Gray mold	*Botrytis fascicularis* (Imperfect fungus)	V, G; V, I
Circular pits with pink spore-fruits	Anthracnose	*Gloeosporium melongenae* (Imperfect fungus)	III, A or D
Circular pits with dark spore fruits; leaves also spotted	Fruit rot and leaf spot	*Phomopsis vexans* (Imperfect fungus)	III, A or D
Fruit rotting rapidly; no spore-fruits, odor of mushrooms	Fruit rot	Rhizoctonia sp. (Sterile fungus)	Use straw mulch to keep fruits off soil
Disease killing or seriously affecting the entire plant:			
Seedlings only attacked; stem dries at ground level	Seedling disease	*Phoma solani* (Imperfect fungus)	VII, A; air-slaked lime about the plants
Plants become yellow, wilt and lower stem is covered with a white mold	Stem rot	*Nectria ipomoeae* (Sac fungus)	See cotton wilt
Sudden wilting without previous yellowing	Wilt	*Bacillus solanacearum*	See tobacco wilt
EGG PLANT (Insects). See *potato insects* and *general garden insects;* also Harlequin cabbage bug under *cabbage insects.*			
Small black active beetles which jump quickly and disappear if disturbed; serious especially on young plants	Potato flea-beetle	*Epitrix cucumeris*	III, X (for young plants) or III, A
EMMER. (See *wheat diseases and insects.*)			
FIG (Diseases). (See also root rot under *cotton diseases.*)			
Troubles affecting the fruit:			
Spots sunken, circular, generally covered with a white mold, and later producing salmon-pink pustules	Fruit rot or anthracnose	*Glomerella cingulata* (Sac fungus)	V, I (fruit) III, A
Fruit sours and becomes very soft and rotten	Soft rot	*Rhizopus nigricans* (Black mold)	XI, Bb; IX, A (and often) X, Ca to keep ants out
Troubles affecting the foliage:			
Brown, angular leaf spots ($\frac{1}{16}$–$\frac{1}{8}$ inch)	Leaf blotch	*Cercospora fici*	III, A if severe
Yellowish-brown spots ($\frac{1}{32}$ inch) not powdery	Rusty leaf	*Cercospora bolleana* (Imperfect fungi)	"
Yellowish-brown, powdery spore-dots on the under surface	Rust	*Physopella fici* (Rust fungus)	None recommended
Troubles affecting the branches:			
Open wound or canker at the fruit scars	Canker	*Tubercularia fici* (Imperfect fungus)	V, I (the diseased branches)
Bright salmon-colored spore-fruits on branches; affected portions show sudden wilting and dying of leaves	Limb blight	*Corticium laetum* (Basidium fungus)	" "
FIG (Insects). See also white fly under *citrus insects;* pear thrips under *pear insects;* and greenhouse thrips under *greenhouse insects.*			
Circular or elongated, flat or convex, brown, gray, or cottony insects, closely appressed to bark, leaves, or fruit	Scale insects	Various species (10 or more)	III, F O or Q (dormant spray)
White, oval insects covered with waxy secretion, suck juice from under surface of leaves	Mealy bugs	Pseudococcus spp. (Mealy bugs)	III, P; III, Z
Beetles boring in twigs; entering generally at a bud or fork, and weakening or severing the branch:			
Dark brown, head narrower than, and at right angles to, thorax, ($\frac{1}{2}$ inch long)	Western twig borer	*Apate punctipennis* (Beetle)	V, I (infested branches)

Black with brown wing-covers, head as wide as the thorax (⅜–⅝ inch long)	Branch and twig borer	*Polycaon confertus* (Beetle)	" "
Irregular enlargements on the roots inhabited by microscopic round worms (Nematodes)	Root knot	*Heterodera radicicola* (Round worm)	VI, F (Crops not susceptible, for 3 years before figs)

FLAX (Diseases)

Plants wilt and die at any age; older plants show more or less yellowing	Wilt	*Fusarium lini* (Imperfect fungus)	I, Ba (1–40, ½ gal. per bushel and dry at once; XI, Bb,; V N
Young plants killed, pronounced ulcer at or near the ground level	Canker	Colletotrichum sp. (Imperfect fungus)	V, N; XI, Bb
Yellow or orange spore-dots on leaves early in season; later black spore dots, mostly on the stems	Rust	*Melampsora lini* (Rust fungus)	XI, Bb

FLAX (Insects). See general *grain and grass insects;* also *general garden insects.*

GARDEN PLANTS (Insects.) See also wire worms, white grubs and army worms under *grain and grass insects;* red spider under *greenhouse insects;* twelve-spotted cucumber beetle under *cucumber insects.*

Yellowish, dark-spotted worms (½–¾ inch) spin webs over plants and skeletonize leaves	Garden web-worm	*Loxostege similalis* (Moth)	III, K; VI, A
Young plants cut off even with the surface or little higher	Cut worms	Various Noctuidae (Moths)	X, A ab or C; VI, A a
Leaf-eating caterpillars not protected by web	Caterpillars	Various moths	III, K or M
Foliage riddled with holes by a small (⅛ inch) cream-colored beetle with striped wing covers	Pale-striped flea-beetle	*Systena taeniata* var. *blanda*	III, A + K
Roots showing various enlargements with streaks or spots of internal dark tissue	Root-knot or nematodes	*Heterodera radicicola* (Round worms)	VIII, E

GINSENG (Diseases)

Disease most evident on the tops:			
Plants wilt and die; "root" in section shows a discolored ring	Wilt	Acrostalagmus sp. (Imperfect fungus)	II (Previous to setting) XI, A
Leaves spotted at least in the early stages of the trouble:			
Leaf spots large, watery first, later brown and papery with yellow borders; leaflets drooping, brown dust on affected parts at point of bending	Alternaria blight	*Alternaria panax* (Imperfect fungus)	III, A (4–5–50) plus resin sticker
Leaf spots without yellow margins, but much like the preceding when young	Mildew or Phytophthora soft rot	*Phytophthora cactorum* (Downy mildew)	III, A
Small to large transparent (often yellow) leaf spots between the main veins	Papery leaf spot	Non-parasitic. Unfavorable soil	Improve soil
Disease most evident on the "roots:"			
Rusty or copper colored on the outside	Rust	Non-parasitic Cause unknown	None known
Roots shrunken and coal-black without	Black rot	*Sclerotinia smilacina* (Sac fungus)	V, N; V, G; II if infected soil can not be avoided
Root and lower part of the stem rotted; hard black bodies (sclerotia) in mold within hollow of diseased stem or on the surface	White rot	*Schlerotinia libertiana* (Sac fungus)	"
Roots with grayish-black spots, not penetrating deep; the end of tap root of seedlings destroyed or deformed	Thielavia root rot	*Thielavia basicola* (Sac fungus)	"

GINSENG (Insects). See *general garden insects.*

GOOSEBERRY (Diseases). See also rust under *currant diseases.*

Young shoots white, powdery and deformed; berries spotted or covered with a brown weft when approaching maturity	Powdery mildew	*Sphaerotheca mors-uvae* (Sac fungus)	III, F (1–40) 1. When leaf clusters are ½ to ¾ inch long. 2. Repeat after 10 to 14 days

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Reddish swollen or thickened spots on leaves or fruit	Rust	*Puccinia grossulariae* (Rust fungus)	Rarely severe
Brown or tawny spots on the leaves	Leaf spots	*Septoria ribis, Cercospora angulata* (Imperfect fungi)	III, A or F. Easily controlled by mildew spray
Twigs dying back from the tip; gray mold develops from buds or breaks in stem, during moist weather	Die back	Botrytis sp.	V, I (burn); V, G
GOOSEBERRY (Insects). See *currant insects,* most of which attack gooseberry also.			
Insects affecting the fruit:			
Small bright yellow maggot feeding in the pulp	Gooseberry midge	*Dasyneura grossulariae* (Fly)	V, I (the infested berries before the flies mature)
Greenish brown-headed caterpillar ($\frac{1}{2}$ inch) feeding within berries	Gooseberry fruit worm	*Zophodia grossulariae* (Moth)	V, I (berries); X B, d (after picking)
Small yellowish or cream-colored beetles (about $\frac{1}{4}$ inch) feeding on leaves and fruit.	Fruit-tree leaf Syneta	*Syneta albida*	None perfected
Larvæ working in base of canes and down into the crown; adult a dull black beetle ($\frac{1}{2}$ inch long)	Black gooseberry borer	*Xylocrius agassizii* (Beetle)	V, I (infested canes)
GOURD. See *cucumber and squash diseases and insects.*			
GRAINS AND GRASSES (Diseases)			
Leaves or culms showing reddish brown or orange powdery spore-dots and black covered or powdery spore dots	Rusts	Puccinia spp. Uromyces spp. (Rust fungi)	See specific cereals; IX, A for grasses
Heads more or less completely destroyed and structures replaced by black smutty masses	Smuts	Ustilago spp. and other smut fungi	See specific cereals. Not serious on grasses
Leaves or culms more or less white powdery	Powdery mildew	*Erysiphe graminis* (Sac fungus)	Not sufficiently severe to need control measures
Seeds or kernels replaced by black horny spurs (Sclerotia)	Ergot	Claviceps spp. (Sac fungus)	IX, A; V, M
GRAINS AND GRASSES (Insects). See also the *specific cereals.*			
Insects working on the roots:			
Plump white grubs feed on the roots and cause more or less injury	White grubs	Lachnosterna spp. (May beetles or June bugs)	VI, F; VI, A b
Seeds, germinating seeds and young seedlings injured or destroyed by slender, yellowish-brown, shiny larvae	Wire worms	*Elateridae* (Various species of click beetles)	VI, F (short rotations) VI, Ab
Naked, tough, cylindrical grubs (1 inch or less) of dark color feeding on the roots	Leather jackets	*Tipulidae* (Various species of crane flies)	VI, F; VI, A (by Sept. 1)
Insects working on the shoots (leaves and stems):			
Black-bodied bug ($\frac{1}{5}$ inch) with white wings, each marked with small black triangle	Chinch bug	*Blissus leucopterus* (Bug)	X, Cc (to prevent migration to corn)
Yellowish-green lice; wingless form $\frac{1}{16}$ inch) with faint dark line down middle of its back	Spring grain aphis or "green bug"	*Toxoptera graminum* (Aphid)	No direct control feasible
Grasshoppers and migratory locusts	Locusts	*Acrididae* (Various species)	V, M; X, B a; X, Cbc; X, A abc
Green or brownish caterpillars frequently moving in great numbers and devouring the vegetation in their path	Army worm	Various species (Moths)	X, Cc; III, K or X, Aa on strip in advance of their march. VI, Aab
Insects working in the harvested grain:			
Small brown snout beetles and their larvae ($\frac{1}{8}$-$\frac{1}{6}$ inch)	Grain weevils	Calandra spp. (Snout beetles)	IV, B ab; I, G; also storage in large bulk
Flat, brown or reddish brown beetles and their larvae	Grain beetles	*Silvanus surinamensis* and Cathartus spp. (Beetles)	" "
White caterpillar ($\frac{1}{5}$ inch) working inside the kernels or grains; adult a small moth	"Fly weevil" or Angumois grain moth	*Sitotroga cerealella* (Moth)	IV, Bab; thresh early; clean granary

GRAPE (Diseases)

Leaves and fruit affected:			
Reddish brown leaf spots; fruits rot and shrivel and become hard and dry	Black rot	*Guignardia bidwellii* (Sac fungus)	V, A, F, G; VI, C; III, A (4-3-50) Five or six applications
Leaf spots yellow above, white powdery below, especially in moist weather; berries may rot but do not become hard and dry	Downy mildew	*Plasmopara viticola* (Downy mildew)	III, A (4-3-50); III, D as fruit matures
Sparse powdery white coating on foliage; fruits white powdery at first, later showing numerous black spore fruits	Powdery mildew	*Uncinula necator* (Sac fungus)	III, F or I; (dust or atomic suphur) Begin when shoots are 6-15 inches long)
Leaves spotted, blotches irregular, dark to almost black	Leaf spot or scab	*Cercospora viticola* (Imperfect fungus)	Controlled by spraying for black rot
Fruit rotted, but foliage not generally attacked:			
Brown or ashen spots surrounded by zone of red, beginning on green fruits (also on canes and leaves)	Bird's-eye rot	*Sphaceloma ampelinum*	Controlled by black rot spraying
Ripe rots	Bitter rots	*Glomerella rufomaculans* *Melanconium fuligenum*	" "
Diseases affecting the canes:			
Irregular black swellings on lower part of trunk or upper part of roots	Black knot or crown gall	*Pseudomonas tumefaciens* (Bacterium)	Not generally serious. VIII, D or VII, G; VI, H (phosphatic manures)
Terminal shoots killed or leaves dwarfed, crimped or blanched; small black spore-fruits in bark of dead spurs	Dead arm or necrosis	*Cryptosporella viticola* (Sac fungus)	V, I (back to the crown if necessary)
Roots and base of trunk rotted:			
Brown, string-like strands on surface of affected roots; toad-stool form from dead crowns	Mushroom root rot	*Armillaria mellea* (Basidium fungus)	V, H; V, N
Shoestring strands absent, white mold-like strands present	Dematophora root rot	*Dematophora necatrix* (Sac fungus)	" " " "
No root-rot; slight or retarded growth with reduced and sickly leaves; entire plants die	Anaheim or California vine disease	Unfavorable environmental conditions	Irrigation, tillage and proper fertilizers
Blossoms drop without setting fruit (Muscats)	Dropping or colure	Failure to pollinate	Add rows of other variety

GRAPE (Insects). See also climbing cut-worms, twig-pruner, tree crickets, flea beetles, San José scale under *apple insects;* grasshoppers and army worms under *garden insects.*

Insects attacking the foliage and eating holes or sucking the juices and sometimes causing leaf galls

Adult beetles or their grubs feeding on the leaves:			
Beetles grayish-brown, long legged ($\frac{1}{3}$ inch) feed on buds, newly-set fruit and foliage	Rose chafer	*Macrodactylus subspinosus* (Beetle)	VI, Bd (May and June) X, Fa; III, K (4-50 + 2 gal. molasses)
Beetles greenish or steel-blue ($\frac{1}{5}$ inch) eat young buds and leaves; later their grubs, dark yellowish brown larva, eat irregular holes from upper surface	Grape vine flea beetle	*Haltica chalybea* (Beetle)	III, K or X, B f
Brown beetles similar to common June beetle but smaller	Vine chafers	Anomala spp. (Beetles)	See rose chafer
Beetles eating characteristic chain-like holes in the leaves:			
Grayish brown ($\frac{1}{4}$ inch)	Root-worm beetle	*Fidia viticida* (Beetle)	III, K (3-50) better if 2 gals. molasses added
Two forms: one black; one with black head and thorax and brown wing covers	California root-worm beetle	*Adoxus obscurus* (Beetle)	III, K (5-50)
Heavy bodied, golden yellow beetles, each wing-cover with 3 black dots (1 inch long)	Spotted pelidnota	*Pelidnota punctata* (Beetle)	III, K or X, F a
Sucking insects attacking the foliage:			
Leaves show minute white spots above; later turn brown and fall; adult insects on under surface ($\frac{1}{10}$ inch) pale yellow with irregular red markings	Vine leaf hopper	*Typhlocyba comes* (Leaf hopper)	V, F, G; VI, C. X, Ba; III, S or V high pressure
Dark soft-bodied lice on tender leaves and shoots	Grapevine aphis	*Macrosiphum viticola* (Aphid)	III, V

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Hollow galls projecting on the under side of the leaves, but opening above	Phylloxera galls	*Phylloxera vastatrix* (Aphid)	See root form
Caterpillars feeding on the leaves:			
Leaf folded, by grass-green larva ($\frac{3}{4}$ inch)	Grape-leaf folder	*Desmia funeralis* (Moth)	III, K
Terminal leaves of shoot webbed together by small, greenish, white-haired caterpillars	Grape-plume moth	*Oxyptilus periscelidactylus* (Moth)	X, Fa; not serious in commercial vineyards
Small yellowish white larvæ feed in rows; eat epidermis first, later holes; adults sulphur yellow, with long bristly hairs ($\frac{3}{4}$ inch)	Grape-leaf skeletonizer	*Harrisina americana* (Moth)	X, Fa; or III, K, if numerous
Greenish yellow larvæ feed in rows; eat whole tissue beginning at edge	Grape vine saw-fly	*Erythraspides pygmaea* (Saw-fly)	III, K
Larvæ marked by orange and black bands and spots ($1\frac{1}{2}$ inch)	Eight-spotted forester	*Alypia octomaculata* (Moth)	X, Fa; III, K
Large greenish or brownish caterpillars, (2-3 inches long)	Hawk moths	Various species (Moths)	X, Fa; or III, K if numerous
Leaves show white felt-like spots on under surface which later turn to rusty brown; caused by minute mites of microscopic size	Erinose of the vine	*Eriophyes vitis* (Mite)	Controlled by III, I for mildew
Insects attacking the fruit or flower buds			
Blossoms buds greatly swollen yellow or reddish and filled with whitish or yellowish maggots ($\frac{1}{12}$ to $\frac{1}{16}$ inch)	Grape-blossom midge	*Contarinia johnsoni* (Midge)	III, V (First when first buds begin to open)
Larvæ working inside the green or ripening berries, dark green to purplish with brown head ($\frac{3}{8}$ inch); an earlier brood works on young berries from the outside	Grape-berry moth	*Polychrosis viteana* (Moth)	III, K (Shortly after fruit sets and 10 days later with 3rd for 2nd brood)
Half-grown or older berries showing egg stings or a minute white legless grub working within; adults a brownish snout beetle ($\frac{1}{10}$ inch or less)	Grape curculio	*Craponius inæqualis* (Snout beetle)	III, K when beetles first appear
Insects attacking the canes			
Galls produced on cane ($1\frac{1}{2}$ inches long by twice diameter of cane) by yellowish white larvæ working in the pith	Grape-cane gall maker	*Ampeloglypter sesostris* (Beetle	Treatment rarely necessary.
Smaller shoots tunneled and killed by dark brown beetle ($\frac{3}{8}$ inch)	Grape-cane borer	*Schistocerus hamatus* (Beetle)	V, I (Spring) V, G (especially all prunings)
Tips of branches girdled, terminal bud and some leaves eaten, and a white footless grub working in the pith	Grape-cane girdler	*Ampeloglypter ater* (Beetle)	" "
Scales brownish ($\frac{1}{4}$ inch) with large white cottony mass protruding from beneath the partially raised body	Cottony maple scale	*Pulvinaria vitis* (Scale insect)	III, N, O or Q (winter); III, V. (summer)
Scales elliptical, flat, pale yellowish-brown ($\frac{1}{16}$ inch) papilla at one side of the centre	Grape scale	*Aspidotus uvae* (Scale insect)	III, F (winter)
Insects attacking the roots			
Plants stunted, leaves yellow; small roots eaten off and larger ones furrowed or stripped of bark by small white grubs	Grape-root worms	*Fidia viticida* *Adoxus obscurus* (Beetles)	VI, B (In June to break up pupae cells) See leaf forms
Root galls or enlargements formed:			
Largest on smaller roots, often at extreme tip, enlargements decay	Phylloxera	*Phylloxera vastatrix* (Aphid)	XI, C; VII, B (flood in fall or winter)
Largest on larger roots, 2 or 3 times diameter of phylloxera galls, none at extreme tips	Nematode galls	*Heterodera radicicola* (Nematodes)	X, Bc; also XI, C.

GRAPE FRUIT. (See *Citrus diseases and insects.*)

GREENHOUSE PLANTS (Diseases)			
White powdery growth covering leaves or stems	Powdery Mildew	*Sphaerotheca, Erysiphe, etc.* (Sac fungi)	Paint sulphur and oil on steam pipes
Seedlings drop over and die	Damping off	Various fungi	II, Ba or Ca
Cuttings rot without rooting	Damping off	Various fungi and bacteria	II, B a or Ca
Black mold growing over surface of leaves	Black mold	Meliola spp.	Control the white fly
GREENHOUSE PLANTS (Insects)			
Leaves showing numerous small whitish spots or a general sickly color, with browning and drying:			
Minute dark-bodied (1/25 inch), or yellowish (1/25 inch) insects working on under surface of leaves; no webs	Thrips or Stigmonose	*Heliothrips haemorrhoidalis. Thrips tabaci*	III, V or IV, C
Very fine webs on under surface of leaves or over flower heads	"Red spider"	*Tetranychus telarius* (Mite)	III, Z or S or I
Active, white-winged insects working mostly on under side of leaves	White flies	Aleurodes spp. (White fly)	IV, Db
Slow-moving, soft-bodied bugs (1/16–1/8 inch) covered with whitish powdery secretion	Mealy bugs	Pseudococcus spp. (Aphid)	III, P or IV, D b
Greenish or dark soft-bodied insects on leaves or succulent stems	Plant lice	*Myzus persicae* and others	III, V
Oblong, slate-gray (1/4–1/2 inch) "bugs" with 7 pairs of legs; roll up when disturbed	Sowbugs	*Porcellio laevis* (Crustacean)	IV, Db; X, Ad; VII, A and avoid crowding
Whitish caterpillar, with median green stripe, (3/4 inch) folds leaves or ties them together with silk	Greenhouse leaf-tier	*Phlyctaenia ferrugalis* (Moth)	X, Fa or III, K before protected
Active greenish or reddish caterpillars roll up leaves, fasten them with silk and feed within	Oblique banded leaf roller	*Archips rosaceana* (Moth)	" "
Buds of various plants eaten but no insects evident (Feeding done at night)	Climbing cutworms	Various Noctuidae (Moths)	X, Aab or c
GUAVA (Disease)			
Circular brown rotted areas on fruit with salmon-colored spore-masses when more advanced	Ripe rot	*Glomerella psidii* (Sac fungus)	No available data; III, A, or F probable
GUAVA (Insects). See scales and mealy bugs under *citrus fruits.*			
HEMP (Disease)			
Leaves wilt, droop, turn brown and die; plants killed	Leaf wilt	*Botryosphaeria marconii* (Sac fungus)	Not perfected
HOP (Disease)			
White powdery coating on the leaves	Powdery mildew	*Sphaerotheca humuli* (Sac fungus)	III, I
HOP (Insects). See also melon aphis and mites under *cantaloupe insects;* potato flea beetle under *potato insects.*			
Larvae working in growing tips, causing "muffle head"; later burrow in stem near ground and work upward	Hop-plant borer	*Hydroecia immanis* (Moth)	V, I (Muffler heads)
Insects attacking the leaves:			
Pale yellowish-green lice cause yellowing of leaves and reduced yield	Hop louse	*Phorodon humuli* (Aphid)	III, V male plants before others are infected
Caterpillars green; (about 1 inch) marked by two white lines down the back	Hop-vine snout beetle	*Hypena humuli*	III, K
Caterpillars black when mature, (1½ inches) head reddish black; body segments with branching spines	Semicolon butterfly	*Polygonia interrogationis* (Butterfly)	III, K when numerous
Caterpillars when mature white, mottled, or striped with gray, body segments with branching spines	Comma butterfly	*Polygonia comma* (Butterfly)	" "

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
HORSE-RADISH (Diseases). See also white rust under *radish diseases.*			
Circular, blanched leaf spots, later coated with a black mold	Black mold	*Macrosporium herculeum* (Imperfect fungus)	Rarely severe
Circular pale spots on leaves, with or without dark spore-fruits, and sometimes causing perforations	Leaf spots or blight	Various imperfect fungi	III, A, effective but rarely needed
HORSE-RADISH (Insects). See *general garden insects*; also Harlequin cabbage bug and imported cabbage worm under *cabbage insects.*			
HUCKLEBERRY (Diseases)			
Pale rose or reddish, thickened spots on foliage, later minutely white powdery	Gall	*Exobasidium vaccinii* (Basidium fungus)	None necessary
Branches thickened, closely clustered, thickenings broken crosswise	Rust	*Calyptospora collumnaris* (Rust fungus)	V, I.
KAFIR CORN. See *sorghum diseases and insects.*			
LEMON. See *citrus diseases and insects.*			
LETTUCE (Diseases)			
Troubles causing more or less spotting of the leaves:			
Depressed, watery spots on midrib, irregular spots or perforations on leaf blade	Anthracnose or shot-hole	*Marsonia perforans* (Imperfect fungus)	VII, A and D, VI, K a
Brown spots showing minute, black spore-fruits	Leaf spot	Septoria sp. (Imperfect fungus)	V, G (old diseased plants)
Spots yellow above, white fuzzy below during damp weather	Downy mildew	*Bremia lactucae* (Downy Mildew)	VI, Ka; also paint sulphur and oil on steam pipes
Entire plant or extended areas of leaves affected:			
Leaves droop and rot; black seed-like bodies (sclerotia) formed in rotting mass	Wilt or drop	*Sclerotinia libertiana* (Sac fungus)	V, H; III, A (around ground). II, B a and VII, E greenhouses
Wilted, flaccid patches of leaves become coated with a gray, powdery or fuzzy growth	Gray mold	*Botrytis cinerea* (Imperfect fungus)	VI, Ka; VII, A, C, or D
A rapid soft rot without the symptoms noted for wilt or gray mold	Soft rot	Bacterial	VII, A
LETTUCE (Insects). See bean thrips; green peach aphis under *peach insects;* Harlequin cabbage bug under *cabbage insects;* white fly under *greenhouse insects;* potato fleabeetle under *potato insects;* also *garden insects.*			
Cylindrical, chestnut brown or black, many-legged "worms" working in either head or roots	Millipeds or thousand-legged worms	Julus spp. (Thousand-legged worms)	X, Ad
Slender, dark metallic bronze or black bugs ($\frac{1}{4}$ inch) suck juices, making yellow spots and later killing the leaves	Black plant bug	*Irbisia brachycerus* (Bug)	III, A or W; III, S or V.
Grayish brown bugs ($\frac{1}{4}$ inch); young reddish brown and wingless; suck juices and cause yellowing and browning of leaves	False chinch bug	*Nysius ericae* (Bug)	VI, C (especially for weed destruction) III, S or V
LIME. See *citrus diseases and insects.*			
LOGANBERRY. See *blackberry and raspberry diseases and insects.*			

LOQUAT (Diseases)			
Dark or olive patches on leaves or fruits	Scab	*Fusicladium eriobotryae* (Imperfect fungus)	III, A or F
Brown leaf spots showing dark spore pustules	Leaf spot	*Entomosporium maculatum* (Imperfect fungus)	See same disease of pear
LOQUAT (Insects). See codlin moth, green apple aphis and scale insects under *apple insects.*			
MANGEL-WURZEL. See *beet diseases and insects.*			
MANGO (Diseases). See *anthracnose of citrus fruits.*			
MANGO (Insects). See scales and mealy bugs under *citrus fruits;* also greenhouse thrips under *greenhouse insects.*			
MELON (Diseases). See *cantaloupe and cucumber diseases.*			
MILLET (Diseases)			
Gray, purple-bordered spots on the leaves	Leaf spot	*Piricularia grisea* (Imperfect fungus)	IX, A
Seeds transformed into masses of black powder	Smut	*Ustilago crameri*	I, A (Formaldehyde)
MILLET (Insects). See *grain and grass insects;* also *12-spotted cucumber beetle.*			
MULBERRY (Diseases)			
Leaves showing dark, brown, more or less circular spots or gray purple-bordered spots	Leaf spots	Cercospora spp. (Imperfect fungi)	III, A or F if severe
Young terminal shoots wilt and turn brown	Blight	Bacterial	V, I and J
MULBERRY (Insects). See cottony maple scale under *maple insects* and scales in general under *tree insects.*			
MUSHROOMS (Diseases)			
Monstrous, soft growths in place of the normal mushrooms	Mushroom mold	*Mycogone perniciosa* (Sac fungus)	Abandon infected beds; clean up and spray with bluestone, 1 lb. to 15 gallons water
Buttons turn brown, cease to grow and soon decay	Fogging-off	Unfavorable conditions; probably too warm	Control temperature
Small, discolored areas on surface of cap	Black spot	Too much water or poor ventilation	Ventilate and VII, A
MUSHROOMS (Insects). See "sow bugs" under *greenhouse insects.*			
Active, wingless insects with 3 bristle-like appendages at the posterior end of the body	Spring tails	Species of Thysanura	IV, B b; V, G (all old bedding)
Larvæ or grubs working in beds or in the mushrooms	Mushroom flies	*Phora minuta* and others	IV, B b; avoid high temperatures
Minute spider-like forms with 8 legs working on the mushrooms or in the spawn	Mites	Various species	Not general; serious at proper temperatures
MUSKMELON. See *cantaloupe diseases and insects.*			
MUSTARD (Diseases). See black rot, downy mildew, and club root under *cabbage diseases;* also white rust under *radish diseases.*			
MUSTARD (Insects). See *cabbage insects;* also *general garden insects;* and lima bean symphlid under *bean insects.*			
NECTARINE. See *peach diseases,* especially brown rot and scab; and also *peach insects.*			

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
NURSERY STOCK (Diseases). See also the specific varieties.			
White powdery growth on leaves and young shoots	Powdery mildew	Various species (Sac fungi)	III, I (Dust is very practical)
Spots of various size and color on leaves, causing yellowing and more or less defoliation	Leaf spots	Various imperfect fungi	III, I or A
Abnormal corky outgrowths on crown or roots. (See also hairy root under apple)	Crown gall	*Pseudomonas tumefaciens* (Bacterium)	V, H; use care in wrapping grafts
NURSERY STOCK (Insects). See also the specific varieties.			
Scales, aphids, twig-borers, etc., on or in nursery stock	Various troubles	Various species	IV, D c
Swellings and galls produced all over the young roots	Root knot	*Nematodes*	V, H; V, N; VI, H a
OATS (Diseases). See also powdery mildew and scab under *wheat diseases;* and anthracnose under *rye diseases.*			
Entire head a black powdery mass with chaff completely destroyed	Loose smut	*Ustilago avenae*	I, Aa or B
Entire head affected, but smutted kernels not powdery enclosed by the chaff	Covered smut	*Ustilago levis* (Smut fungi)	Ditto
Stem and leaf sheaths with elongated brown or black granular streaks	Stem rust	*Puccinia graminis*	XI, B a (Early maturing)
Leaf sheaths and blades with small, orange, powdery spore-dots or black, covered ones	Crown rust	*Puccinia coronifera* (Rust fungi)	XI, B a (Early maturing)
Leaves partially or generally collapsed and mottled to red in color	Bacterial blade blight	*Pseudomonas avenae* (Bacterium)	XI, B. b
OATS (Insects). See *grain and grass insects;* wheat midge, louse and stem maggots under *wheat insects;* red spider under *clover insects.*			
Black or grayish-black bugs suck juices from leaves and cause small yellow spots or general yellowing and death:			
Dark metallic bronze or black ($\frac{3}{16}$–$\frac{1}{4}$ inch)	Black plant bugs	Irbisia spp. (Bug)	Control measures not generally necessary. X, B a
Grayish-black with clouded membrane at tips of wings ($\frac{3}{16}$ inch)	Pacific plant bug	*Thyrillus pacificus* (Bug)	Control measures not generally necessary. X, B a
Yellowish or dark green soft-bodied insects on leaves and stems	Oat aphis	*Aphis avenae* (Aphid)	VI, F; VI, C (during winter)
OKRA. See wilt and root-rot under *cotton diseases;* corn ear-worm under *corn insects;* Harlequin cabbage bug under *cabbage insects;* two-spotted mite or red spider under *bean insects;* also *general garden insects.*			
OLIVE (Diseases). See sooty mold under *citrus fruits;* also mushroom root-rot under *apple diseases.*			
Irregular galls or outgrowths on twigs or stems	Knot or tuberculosis	*Bacillus savastanoi* (Bacterium)	V, I and J
Small leaf spots showing concentric rings of different colors	Peacock leaf spot	*Cycloconium oleaginum* (Imperfect fungus)	III, A or F not generally necessary
Large, dry, sunken spots on the fruit	Dry rot	Unknown but non-parasitic	None known
OLIVE (Insects). See scale insects and citrus thrips under *citrus insects;* also branch and twig borer under *oak insects.*			
ONION (Diseases)			
Troubles most evident on the bulbs:			
Internal soft rot or outer scales softened to make "slippery onions"	Soft rot	Bacillus spp.	IX, D under dry conditions
Rotting slowly from the base; white mold evident when cut onion is kept moist	Dry rot	Fusarium sp.	V, N; VI, F; IX, D
Outer scales of bulbs with concentric black rings	Anthracnose or smudge	*Vermicularia circinans* (Imperfect fungi)	IX, D under dry conditions; V, I

Neck of onion blackened (appears on white onions cut before maturity) . . .	Dry or black neck-rot	*Sclerotium cepivorum* (Sterile fungus)	Keep dry and well aërated during curing
Trouble evident on both leaves and bulb: Young seedlings with dark opaque spots; older plants with bulb scales broken and shrunken to expose powdery black mass	Smut	*Urocystis cepulae* (Smut fungus)	V, N; V, F and G; II, A or B for small plots; II, by drip attachment on drill using formalin
Trouble most evident on the foliage: Leaves wilt, droop and die. When moist, covered with a gray, powdery mold	Gray mold	Botrytis sp. (Imperfect fungus)	See downy mildew
When moist, covered with white mold, powdery from spore production . . .	Downy mildew	*Peronospora schleideniana* (Downy mildew)	III, A (5-5-50) V, F (tops) VII, F; VI, F
Leaves blight and are later covered with a black velvety mold (May follow gray mold or downy mildew).	Black molds	Macrosporium spp. (Imperfect fungi)	Controlled by treatment for downy mildew
Brown, powdery spore-dots on the leaves	Rust	*Puccinia porri* (Rust fungus)	Not yet serious in America, VI, F; V, H
Entire plants affected. Undersized, yellow or off color; leaves sometimes twisted and very brittle; roots with abnormal thickenings	Brittle	*Fusarium* (Imperfect fungus)	VI, F; VI, G b for the year in onions

ONION (Insects). See *general garden insects;* also wire-worms under *grain and grass insects.*

Insects affecting the bulbs: Small maggots work in the developing bulbs and cause direct injury or induce rotting	Onion maggots	*Pegomya cepetorum* *Chaetopsis aenea* (Flies)	VI, F; get as far from old fields as possible. Treatments of little value
Insects affecting the tops. A minute, slender, yellowish insect ($\frac{1}{25}$ inch) sucks the juices and causes numerous tiny white spots	Thrips or "white blast"	*Thrips tabaci* (Thrips)	V, G (clean up old tops in fall) III, V

ORANGE. See citrus diseases and insects under *citrus fruits.*

PARSLEY. See drop or wilt of lettuce under *lettuce diseases;* also *celery and parsnip insects.*

PARSNIP (Diseases). See *leaf spot or early blight of celery.*

Plants stunted, leaves yellowed or blighted, brown fungous threads on the roots . .	Rhizoctonia disease	*Corticium vagum* var. *solani* (Basidium fungus)	V, N; VI, H b

PARSNIP (Insects). See also *garden insects.*

Soft-bodied, pale green insects with few small red spots on back	Parsnip louse	*Siphocoryne capreae* (Aphid)	III, V
Numerous irregular mines in leaves; made by yellowish white or greenish maggots ($\frac{1}{4}$ inch)	Parsnip leaf miner	*Acidia fratria* (Fly)	III, V (1-400) or III, P repel egg layers

PEA (Diseases).

Leaves and stems with white powdery coating; later showing many minute black spore-fruits	Powdery mildew	*Erysiphe polygoni* (Sac fungus)	III, I (dust for large fields) III, F for garden
Circular, sunken, dark-bordered brown or grayish spots on pods; leaves also spotted.	Pod spot or blight	*Mycosphaerella pinodes* (Sac fungus)	XI, A. XI, Bb. VI, F
Leaves with similar spots but pods little affected	Leaf spot	*Septoria pisi* (Imperfect fungus)	VI, F; V, G (at end of season)
Leaves with brown or black, powdery spore-dots	Rust	*Uromyces pisi* (Rust fungus)	V, B (Spurge, *Euphorbia cyparissias*)
Plants with yellow or blighted leaves or undersized; brown fungous threads on roots; basal portion of stem may show brown ulcers near ground level	Root-rots	Rhizoctonia sp. *Thielavia basicola*	V, N

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
PEA (Insects). See also *bean insects; general garden insects;* wire-worms, white grubs, etc., under *grain and grass insects;* corn ear-worm and seed-corn maggot under *corn insects.*			
Peas hollowed out by larvae; contain either larvae, pupae, or adults or show round exit holes; adult beetles brownish black (⅛ inch) with white spots on wing covers	Pea weevil	*Bruchus pisorum* (Beetle)	IV, Ba; VI, F
Large, pea-green lice (⅛ inch) with long legs and prominent dark-red eyes, feed on tender leaves and stems	Pea aphis	*Macrosiphum pisi* (Aphid)	III, V; Brush from vines just before cultivating
PEACH (Diseases). See brown rot under *plum diseases;* crown-gall and mushroom root-rot under *apple diseases;* silverleaf under *plum diseases;* and Texas root-rot under *cotton diseases.*			
Diseases most evident on the leaves:			
Leaves thickened, curled and reddish or yellow, never normal green	Leaf curl	*Exoascus deformans* (Sac fungus)	III, A or F (Fall or before buds start in spring)
Leaves not thickened, reddish and showing brown spots or perforations (spotting and gumming on twigs); early defoliation	Black spot, Bacterial shot-hole	*Pseudomonas pruni* (Bacterium)	V, I Careful pruning, cultivation and spraying help
Leaf spots yellowish above, with orange powdery spore-dots below	Rust	*Tranzschelia punctata* (Rust fungus)	III, A or F before buds start
Leaf spots yellow above, delicate frost-like appearance below	Frosty mildew	*Cercosporella persicae* (Imperfect fungus)	Not in itself serious
Leaves with brown, circular spots or shot-holes (Fruit not affected)	Leaf spots or shot-holes	*Cercospora circumcissa* *Phyllosticta circumcissa* (Imperfect fungi)	Controlled by other sprayings
Diseases affecting leaves, twigs and fruits:			
Fruit showing white, powdery patches; leaves and twigs also white powdery	Powdery mildew	*Sphaerotheca pannosa* (Sac fungus)	III, I or G
Fruits showing brown, freckle-like spots; brown or purple spots on leaves and twigs	Scab or freckle	*Cladosporium carpophilum* (Imperfect fungus)	III, G (8-8-50) 1. 4-5 weeks after petals fall 2. 3-4 weeks later
Fruits with raised pustule-like spots; leaves brown spotted or perforated; young twigs also spotted and buds killed	California blight. Pustular spot (Ohio)	*Coryneum beijerinckii* (Imperfect fungus)	III, A (6-6-50) about Nov. 1 for Cal. Also III, G (8-8-50) 2 or 3 times, first in May
Diseases affecting fruits:			
Dropping of fruit before maturity	June drop	Unfavorable environment	Keep trees vigorous but prevent overbearing
Pit split, broken or poorly developed; more or less gumming	Split pit and fruit gumming	Unfavorable climatic or soil conditions	Uncertain
Small or extended russet patches	Frost russeting	Low temperatures	X, H if in frost belt
Diseases affecting the twigs, limbs or trunk:			
Twigs or limbs killed back, with or without canker formation; amber colored spore-threads from the bark pustules, following moist periods	Die-back	*Valsa leucostoma* (Sac fungus)	V, I; III, A or F (dormant or winter spray)
Trees normal in fall, but fail in spring or produce but poor growth	Winter injury	Unfavorable temperatures	Control growth and mature wood by VI and VII
Diseases affecting the entire tree:			
Fruits prematurely ripe, red-spotted, without and within; leaves yellowish, undersized and wrinkled or rolled	Yellows	Non-parasitic but infectious	V, H (promptly each year)
Fruits delayed in ripening, undersized	Little peach	Non-parasitic	V, H (Burn)
No fruit; compact clusters or rosettes of leaves	Rosette	Non-parasitic	V, H

PEACH (Insects). See also green fruit-worms, bud-moth, oblique-banded leaf-roller, leaf-crumpler, apple-tree tent-caterpillar, forest tent-caterpillar, climbing cutworms, San José scale, scurfy scale, flat-headed apple-tree borer, twig pruner, twig girdler, flea beetles, and red spider or two-spotted mites, under *apple insects*; pear thrips, Howard scale, European-pear scale, plum curculio, plum plant louse, rusty brown plum aphis, European fruit Lecanium and plum Pulvinaria under *plum insects*; walnut scale under *currant insects*; grape cane-borer under *grape insects*; and umbricated snout beetle under *strawberry insects*.

Insects boring in the crown, trunk or larger branches:			
White or yellowish "worms" (1–1½ inches) burrowing under the bark around the crown	Peach-tree borer Pacific peach-tree borer	*Sanninoidea exitiosa* *Sanninoidea opalescens* (Moths)	X, Fb (dig out then mound up dirt 6–8 inches around crown) X, D d afterward as protective wash
Pinkish or translucent "worms" burrowing under bark of crown, trunk or larger branches. Smaller than the peach-tree borer	Lesser peach-tree borer	*Sesia pictipes* (Moth)	Ditto if serious
Small beetles or their grubs (3/16 inch) burrowing in sapwood and bark of trunk or larger branches:			
Main egg burrow simple with feeding tunnels starting out at right angles	Fruit tree bark-beetle	*Scolytus rugulosus* (Beetle)	Keep tree vigorous; V, G. V, H (severely infested trees) X, D a (carbolated)
Main egg burrow with a y-shaped end, but similar lateral tunnels	Peach bark-beetle	*Phloeotribus liminaris* (Beetle)	Ditto
Reddish brown larvae boring in the pith of tender shoots causing them to wilt and die (second brood attacks fruit also)	Peach twig borer	*Anarsia lineatella* (Moth)	III, F (just after the buds begin to swell)
Insects feeding on leaves or tender shoots:			
Dirty, yellowish-white caterpillars with 6 longitudinal reddish-brown stripes (⅜ inch when mature)	Striped peach-worm	*Gelechia confusella* (Moth)	III, K (2–50 plus 2 pounds lime)
Pale bluish-green larvæ eat out strips from edge of leaf toward the centre, and later roll over portions making them into cases	Peach saw-fly	*Pamphilius persicus* (Saw-fly)	III, K (2–50) just after eggs hatch
Leaves skeletonized by smooth, shining larvae covered with viscid slime	Peach "slug"	*Caliroa amygdalinia* (Saw-fly)	III, K or V
Small soft-bodied insects (lice) sucking the juices from leaves and tender shoots:			
Dark brown or black (also live on roots and cause stunting and yellowing of the foliage)	Black peach aphis	*Aphis persicae-niger* (Aphid)	XI, A (only sure by IV, D c); or X, J b (tobacco decoction); III, V for aerial forms
Pale green or greenish yellow lice attack blossoms and young fruits as well as leaves	Green peach aphis	*Myzus persicae* (Aphid)	III, N (5%), Q or V just as the buds are swelling
Inactive insects closely appressed to bark (Scales). See also other scales listed for peach:			
Scales nearly circular (1/12 inch) orange-red to black, very convex, and edge with radiating dark lines	Terrapin scale	*Lecanium nigro-fasciatum*	III, Q (Winter or early spring)
Scales nearly circular (1/10 inch) dirty white in color	White peach scale	*Aulacaspis pentagona* (Scale insects)	III, F as for San José scale
Insects attacking the fruit:			
Large velvety green beetles (1 inch or less in length) feed on ripening fruit	Green June beetle	*Allorhina nitida* (Beetle)	X, F a; VI, H use fertilizers, not manure; clean up compost heaps
Large yellowish-brown beetles (½ inch or more in length) with wing covers marked with small irregular, black dots, feed on ripening fruit	Brown fruit chafer	*Euphoria inda* (Beetle)	X, F a
Terminal bud withered and killed; laterals forced and blighted in a similar way, giving young trees a bushy form	Stop-back	Blamed on various insects, especially the tarnished plant bug	Control not perfected

PEANUT (Diseases). See also bacterial blight under *tomato diseases*.

Small brown spots on leaves and stems; yellowing and shedding of leaves	Leaf spot	*Cercospora personata* (Imperfect fungus)	VI, F; V F; III (not practical)
Shells rot and show red fungous fruits on the surface	Red rot	*Neocosmopara vasinfecta* + Excessive moisture	IX, A
Fungous threads and small seed-like bodies (brown when mature) on surface of rotting shells	Sclerotial rot	*Sclerotium rolfsii* (Sterile fungus)	No control measures perfected

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL

PEANUT (Insects). See smaller corn stalk-borer under *corn insects;* two-spotted mite or red spider under *apple insects;* and cucumber beetles (*Diabrotica*) under *cucumber insects.*

PEAR (Diseases). See also bitter rot, black rot, brown rot, brown bark spot, black spot canker or anthracnose, crown gall, fire blight; fly speck, powdery mildew, fruit rots, mushroom root-rot, and rough bark disease under *apple diseases.*

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Troubles affecting leaves, twigs, and fruit:			
Olive green or black velvety spots; twigs roughened; fruit spots brown and corky when old	Scab	*Venturia pyrina* (Sac fungus)	See apple scab. Treatment same except III, A before buds expand
Reddish, brown or almost black spots on leaves and fruit; one or more small, black spore dots to each spot	Black spot leaf blotch	*Fabræa maculata* (Sac fungus)	Same as for scab
Black superficial mold	Sooty mold	Apiosporium sp.	Controlled by spraying for pear psylla (insect)
Clusters of orange-colored spore cups on under surface of leaves; also on twigs and fruits	Rust	Gymnosporangium spp. (Rust fungus)	V, B (cedar trees) XI, B b
Troubles affecting leaves only:			
Ashy, gray angular, sharply defined spots with a few black spore-fruits	Ashy leaf spot	*Mycosphaerella sentina* (Sac fungus)	Controlled by later scab sprayings
Irregular brown spots generally bounded by the principal veins	Leaf blight	*Cercospora minima* (Imperfect fungus)	Not serious if sprayed for scab
Trouble affecting fruit only:			
Reddish brown spots or blotches, or irregular rusty patches	Brown blotch	*Macrosporium sydowianum* (Imperfect fungus)	III, A (July)

PEAR (Insects). See also codlin moth, green fruit worms, bud-moth, cigar-case bearer, click beetles, fruit-tree leaf-roller, oblique-banded leaf-roller, leaf crumpler, leaf hoppers, serpentine leaf-miner, white-marked tussock moth, fall web-worm, apple-tree tent-caterpillar, forest tent-caterpillar, red-humped apple caterpillar, climbing cutworms, apple leaf aphis, rosy apple aphis, apple bud-aphis, wooly aphis, San José scale, oyster-shell scale, scurfy scale, Putnam's scale, greedy scale, round-headed apple tree borer, flat-headed apple tree borer, twig pruner, twig girdler, flea beetles, clover mite and eye-spotted apple-twig borer, under *apple insects;* plum curculio, American plum borer, European fruit-tree scale and European fruit Lecanium under *plum insects;* cherry scale under *cherry insects;* walnut scale under *currant insects;* rose chafer under *rose insects;* grape-cane borer under *grape insects;* cottony maple scale under *maple insects;* imbricated snout beetle and tarnished plant bug under *strawberry insects;* and mealy bugs, citrus thrips, citrus red spider, and citrus white fly under *citrus fruit insects.*

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Insects attacking the leaves:			
Small, slug-like, slimy larvæ feed on upper surface of leaves and skeletonize them	Pear slug	*Eriocampoides limacina* (Fly)	III, X (lime for few trees) III, K or V for many
Light green larvæ (½ inch) eat nearly circular holes in leaves and along their margins	California pear saw-fly	*Gymnonychus californicus* (Saw-fly)	III, K when young first appear
Leaves curled and showing a rusty discoloration; conspicuous on tender tips (insects microscopic)	Rust mite	*Epitrimerus pyri* (Mite)	See blister mite
Small light green or reddish swellings, later turning to dark brown or almost black (also attacking fruit)	Blister mite	*Eriophyes pyri* (Mite)	III, F or I (Just as the buds are opening)
Leaves turn yellow, curl and later become brown or black and fall; injury caused by minute cicada-like insects ($\frac{1}{10}$ inch) which secrete honey dew (See Apiosporium under pear diseases)	Pear psylla	*Psylla pyricola* (Jumping plant lice)	V, G; scrape off rough bark; III, V (1-800 on warm winter or spring days, or after the petals fall [1-1000]; repeat in 4 days)

Insects affecting the fruit. (See also codlin moth and others in above list):			
Fruits knotty, deformed and gritty in texture; depressions or pits due to retarded growth caused by feeding punctures	False tarnished plant bug	*Lygus invitus* (Bug)	III, V (1–1000) about when petals fall
Insects attacking especially the buds and blossoms:			
Leaves and blossoms stunted or blasted and setting of fruit prevented by minute dark brown or nearly black insects (1/20 inch). Fruits that do set may be scabbed or deformed	Pear thrips	*Euthrips pyri* (Thrips)	VI, A a b plus several harrowings; III, V (1–1000) as buds begin to open, and after petals fall
Young fruits first abnormally enlarged, later stunted and deformed by numerous minute whitish larvae working within	Pear midge	*Contarinia pyrivora* (Midge)	VI, B (frequent and shallow during June and July); VI, H (Kainit, 1000–2000 lbs. per acre for sandy soils)
Borers working in trunk or branches:			
Making winding tunnels in the sapwood; adult beetle slender shining, bronze-brown (⅓ inch)	Sinuate pear borer	*Agrilus sinuatus* (Beetle)	V, H or I; X, F b; X, Df
Making tunnels in or below the bark, but not in the sapwood; adult a clear-winged moth with expanse of ¾ inch	Pear borer	*Sesia pyri* (Clear-winged moth)	Ditto. Rarely serious however
Twigs or small branches die back in June with symptoms similar to fire blight; minute dark brown beetles (⅛ inch or less) or their grubs working within	Pear-blight beetle	*Xyleborus dispar* (Ambrosia beetle)	V, H, I (before beetles emerge); III, P (June)
Scales working on bark or fruit:			
Mature scales circular, equal to San José scale in size but paler with dull orange papilla to one side of centre; surface of fruits pitted; pits surrounded by zone of red	Howard scale	*Aspidotus howardii* (Scale insect)	See San José scale under apple insects
Mature scales circular or slightly elongated, glossy dark gray, with bark brown central papilla; body dark wine-red or purplish	European or Italian pear scale	*Epidiaspis piricola* (Scale insect)	See San José scale under apple insects

PECAN (Diseases). See also crown-gall under *apple diseases.*

Troubles affecting leaves only:			
Leaf spots ashen gray, with brown border above, nearly black below	Nursery spot or blight	*Phyllosticta caryae*	III, A; V, F
Leaf spots brown above and below, or with darker brown border	Brown leaf spot	*Cercospora fusca* (Imperfect fungi)	III, A; V, F
Troubles affecting both leaves and fruits:			
White powdery coating	Powdery mildew	*Microsphaera alni* (Sac fungus)	III, A or I
Irregular, black, slightly sunken blotches on the developing nuts	Anthracnose	*Glomerella cingulata* (Sac fungus)	III, A (Not yet thoroughly tested)
Diffuse brown spots on leaves and fruits	Scab	*Fusicladium effusum* (Imperfect fungus)	III, A
Trouble affecting entire tree:			
First evident through production of under-sized, crinkled, yellow-mottled leaves; axes of growth shortened and leaves clustered	Rosette	Non-parasitic. Unfavorable soil relation	V, H for seriously diseased trees; good care and fertilization
Trouble affecting the kernel only:			
Dark brown or black spots visible only upon removal of shell	Kernel spot	*Coniothyrium caryogenum* (Imperfect fungus)	V, I (the diseased nuts)

PECAN (Insects). See also *general tree insects;* fall web-worm under *apple insects;* oak pruner under *oak insects;* hickory borer and hickory bark beetle under *hickory insects;* and cottony maple scale under *maple insects.*

Caterpillars or larvæ eating leaves or buds:			
When nearly mature blackish, with 2 white lines along either side (1½–2 inches); covered with dirty white hairs	Pecan caterpillar	*Datana integerrima* (Moth)	X, E (when collected to molt) V, I (young colonies) also III, K
Body grayish, resembling bark in color (more than 3 inches when mature)	"Alligator worms"	Catocala spp. (Moth)	III, K; X, F a (put on loose bands of burlap)
Caterpillars much smaller (⅓ inch) living in a case made from bits of bark, excrement and silk; eat young leaves and sometimes tie them together in bunches	Pecan case-bearer	*Acrobasis nebulella* (Moth)	See bud-moth

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Caterpillars small (about ½ inch) when mature feed on the opening buds; later on expanded leaves, which are folded over to form protecting tubes.	Pecan bud-moth	*Proteopteryx deludana* (Moth)	III, F (Just before buds open in spring)
Twigs girdled in fall by dark gray long-horned beetle; soon fall to ground.	Twig girdlers	Oncideres spp. (Beetle)	F, I (the fallen twigs)
Grub feeds on kernel and later emerges leaving a hole through the shell.	Nut weevil	*Balaninus caryae* (Snout beetle)	IX, A, followed by IV, B a
Larvæ boring in branches, trunk or roots:			
Large grub (3 inches) working in roots	Live-oak root-borer	*Mallodon melanopus* (Long-horned beetle)	X, F b; IV, B a
Smaller larva makes spiral burrows in sapwood.	Pecan tree-borer	*Sesia scitula* (Clear-winged moth)	X F b; also protect wounds and grafts

PEPPER (Diseases). See Rhizoctonia under *bean diseases.*

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Fruits with large, brown, sunken areas with zonately arranged black spore-fruits.	Anthracnose	*Colletotrichum nigrum*	
Fruits with brown more or less terminal dead areas without fungi or showing a black superficial mold.	Blossom-end rot	Non-parasitic. Unfavorable soil relation	Cultivate well to control moisture supply
Leaf spots circular or nearly so, grayish brown with darker border, surrounded by halo of yellow	Leaf spot	*Cercospora capsici* (Imperfect fungus)	III, A or F if serious
Leaf spots small irregular, brown with watery border.	Leaf spot	Bacterial	None perfected
Plants wilt, leaves lose color and dry up; stem near ground level shrunken, discolored and bearing fungous threads and whitish or dark brown bodies (sclerotia) about size of mustard seed.	Southern blight or wilt	*Sclerotium rolfsii* (Sterile fungus)	III, D (on ground and around base of stem); VI F III, A or F

PEPPER (Insects). See army worm under *grain and grass insects;* corn ear worm under *corn insects;* serpentine leaf miner under *cotton insects;* white fly and two-spotted mite under *greenhouse insects;* flea beetle under *potato insects;* and green peach aphis under *peach insects.*

PERSIMMON (Diseases)

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Black spots with yellow border on upper surface of leaves.	Black spot	*Cercospora fuliginosa*	III, A or F if severe
Brown leaf spots with dark border on upper surface of leaves.	Leaf spot	*Cercospora kaki* (Imperfect fungi)	III, A or F if severe

PERSIMMON (Insects). See scales, white fly, and mealy bugs under *citrus insects;* Fuller's rose beetle under *rose insects;* also *general tree insects.*

PINEAPPLE (Diseases)

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Troubles showing on fruit:			
Blackening of central axis or black patches in the pulp.	Black heart	Non-parasitic + molds	Due to excessive moisture
Rotting without above symptoms.	Fruit rot	Various fungi	XI, B; protect cut surfaces with wax; IV, A (1,200 cc. to 1000 cu. ft.)
Troubles affecting the foliage:			
Plants turn first from green to red, then to yellow, later to brown and finally wither	Wilt	Cause uncertain Root fungus (?)	V, H; lime soil from which plants are taken
Leaves long and slender, later assuming the form of rod-like bundles.	Spike or long leaf	Excessive use of acid phosphate	XI, A; VI, H (dried blood, bone meal or other organic fertilizer)
Leaves turn yellow and dry up; roots wound or twisted into a compact mass	Tangle foot	Non-parasite Poorly prepared soil	Take pains in preparing of soil

PLUM (Diseases). See silver leaf under *apricot diseases;* fire blight, crown gall and Armillaria root-rot and winter injury under *apple diseases*, bacterial gummosis and powdery mildew under *cherry diseases;* California blight, die-back, black spot or bacterial spot, rust, scab rosette, yellows and little peach (plum) under *peach diseases.*

Diseases affecting the fruit:			
Fruits enlarged, hollow and later covered with a white powdery coating; finally shrivel and turn brown	Plum pockets or bladder plums	*Exoascus pruni* (Sac fungus)	V, H or I; III, F (before flower buds open and just after petals fall)
Fruits showing a brown, soft rot with approaching maturity; producing tawny, powdery spore tufts, and forming persistent mummies. (May also cause a blossom or twig blight and cankers)	Brown rot	*Sclerotinia cinerea* (Sac fungus)	III, G; V, I (mummies cankers and blighted limbs)
Twigs or branches showing brown or black elongated enlargements	Black knot or plum wart	*Plowrightia morbosa* (Sac fungus)	V, I (branches showing knots; cut 6 inches below knot) III, A
Leaves showing brownish spots, and irregular perforations; more or less yellowing and defoliation	Leaf blight or shot-hole	*Coccomyces prunophorae* (Sac fungus)	V, F; III, I (Dust) or G (10-10-50); or A (2-4-50); or F (1-40)
Leaves on branch or a whole tree wilt and turn brown; branch or whole tree may be killed	Wilt	*Lasiodiplodia triflorae* (Imperfect fungus)	V, J; XI, C, (avoid peach); control black spot and borers

PLUM (Insects). See also lesser apple worm, green fruit worms, bud-moth, cigar-case bearer, fruit-tree leaf-roller, oblique-banded leaf-roller, apple-leaf skeletonizer, leaf-crumpler, canker-worm, white-marked, tussock-moth, tent-caterpillars, red-humped apple caterpillar, apple bud-aphis, tree-hoppers, buffalo tree-hoppers, San José scale, oyster-shell scale, Putnam's scale, flat-headed borer, twig-pruner, twig-girdler, flea-beetle, clover-mite, two-spotted mite and snowy tree cricket under *apple insects;* pear thrips, slug, Howard scale, and European pear scale under *pear insects;* cherry scale and cherry fruit saw-fly under *cherry insects;* borers, fruit-tree bark-beetle, terrapin scale, green June beetle, and white peach scale under *peach insects;* walnut scale under *currant insects;* rose chafer under *rose insects;* cottony maple scale under *maple insects;* and hop plant louse under *hop insects.*

Insects attacking the fruit:			
Young fruits show round feeding punctures or crescentic egg-punctures; older stung fruits show white or yellowish grub which burrows down to the pit; premature dropping	Plum curculio	*Conotrachelus nenuphar* (Snout beetle)	VI, B (July and August) V, I (fallen fruits) X, B f; III, K (2½-50) in III, A (2-3-50) after petals fall and two weeks later
Young fruits show feeding or egg punctures; older stung fruits show milk-white grubs feeding on the kernel; no premature dropping	Plum gouger	*Coccotorus scutellaris* (Snout beetle)	As for curculio but first spray just before blossoms open
Insects attacking the leaves:			
Larvæ grayish above, pinkish or yellow below (mature ¾ inch), feeding under cover of webs and forming unsightly nests	Plum web-spinning-saw-fly	*Neurotoma inconspicua* (Saw-fly)	III, K before large webs are formed
Small steel-blue beetles (⅛ inch) feeding on leaves in June and July	Plum leaf beetle	*Nodonota tristis* (Flea beetle)	III, K (2-50) when beetles first appear
Soft-bodied insects sucking juices from leaves and tender shoots:			
Yellowish-green in color	Plum plant louse	*Myzus mahaleb* (Aphid)	III, V before leaves curl
Light green with fine, white, powdery covering	Mealy plum louse	*Hyalopterus arundinis* (Aphid)	III, V, effective; no curling of leaves
Dark rusty brown in color	Rusty brown plum aphis	*Aphis setariæ* (Aphid)	III, V before leaves curl; III, F as for scale
Insects affecting the trunk or branches:			
Larvæ eat out winding burrows next the sapwood; make dead areas of bark or girdle the tree	American plum borer	*Euzophera semi-funeralis* (Moth)	X, F
Closely appressed to bark:			
Circular ($\frac{1}{16}$ inch) dark, ashy gray, papilla orange-colored, to one side of centre	European fruit-tree scale	*Aspidiotus ostreaeformis* (Scale insect)	Same as San José scale. See apple
Oblong or sub-circular ($\frac{1}{8}$–$\frac{3}{16}$ inch) very convex, brown	European fruit Lecanium	*Lecanium corni* (Scale insect)	III, N, O or Q (Winter)

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
POMEGRANATE (Diseases)			
Leaf spots angular or rounded, brown, indefinite edge; spores borne on surface tufts	Leaf spot	*Cercospora lythracearum*	III, A or F if severe
Leaf spots with minute black immersed spore-fruits	Leaf spot	*Phyllosticta punica* (Imperfect fungi)	" "
POMEGRANATE (Insects). See scales, white fly, and citrus thrips under *citrus fruit insects.*			
POMELO. See *citrus fruit diseases and insects.*			
POTATO (Diseases)			
Diseases confined to the tubers or also attacking the tops			
Tubers normal to outward appearance:			
Black in the centre, with a more or less evident hollow in advanced stages	Black heart	Too high temperatures	IX, E
Pronounced hollow in centre surrounded by brown tissue	Hollow heart	Non-parasitic	VII, A; VI, K b
Spots of brown tissue scattered throughout the interior	Internal brown spot	Potash hunger	VII, B; VI, H (potash and possibly phosphorus)
Network of narrow brown strands throughout interior or localized near stem end	Net necrosis	Frost or poor soil	See internal brown spot
Vascular ring at stem-end darkened, generally darker in Verticillium than in Fusarium	Wilt	Fusarium spp. *Verticillium alboatrum* (Imperfect fungi) *Bacterium solanacearum* (Bacterium)	V, N; X, Cc. XI, A
Tubers with evident external discolorations or blemishes or malformed:			
Showing the color of leaf green	Sunburn	Exposure to sun	Control Rhizoctonia and hill up to cover tubers
Strands or threads of violet fungous filaments running over the surface	Violet Rhizoctonia	*Rhizoctonia crocorum* (Sterile fungus)	V, N; X, C c, XI, A
Black bodies, "dirt that will not rub off" on surface; may be corroded, cracked or pitted	Rhizoctonia disease	*Corticium vagum* var. *solani* (Basidium fungus)	V, N; VI, F; I, D; VI, H a or b; XI, A b c or d
Silvery gray spots or extended areas becoming darker if kept moist in storage	Silver scurf	*Spondylocladium atrovirens* (Imperfect fungus)	XI, A b or d; I, D (hot more effective)
Rough, brownish, irregular patches or extended areas, elevated, level or slightly depressed	Common scab	*Actinomyces chromogenus* (Bacterium)	V, N; VI, F; I, A; II, C c; VI, G a or b; XI, b or d
Circular or oval spots, depressed granular centre, bordered by ragged and ruptured margins of corky skin	Powdery scab	*Spongospora subterranea* (Slime mold)	XI, A b, c or d; I, D (hot 111-113° F, for 5 minutes) VIII, D
Brown nodular excrescences originating from the eyes and varying in size from that of a pin head to those involving the entire tuber	Wart disease	*Chrysophlyctis endobiotica* (Pond scum parasite)	V, N; XI, A
Tubers showing a more or less evident rot:			
Dense white aggregates of fungus in form of irregular sheets or layers with intervening portions of undestroyed potato tissue	Mushroom root rot	*Armillaria mellea* (Basidium fungus)	V, N
Superficial brown or blackish discoloration penetrating ⅛ to ¼ inch (in storage) or causing a wet rot in the field	Late blight rot	*Phytophthora infestans* (Downy mildew)	III, A; XI, A; IX, D
Dry rots beginning at stem end or at some wound, brown or nearly black	Dry rots; Black rots	Fusarium spp. (Imperfect fungi)	V, N; XI, A; IX, B and D
Stem-end develops a soft watery rot	Jelly-end rot	Fusarium spp. + soil conditions	V, N; XI, A
Soft rot penetrating rapidly; brown watery liquid exudes when tubers are broken by handling or by pressure in sacks	Leak or melters	*Rhizopus nigricans* *Pythium debaryanum*	IX, B and E; V, G

Tubers soften and give out a watery exudate; affected parts may dry and show a dark line between affected and normal parts or rots may enter and destroy the tuber	Frost injury	Low temperatures	Protect from frost
Diseases producing discoloration, spotting, or blighting of the foliage ***or an abnormal condition of the shoots***			
Leaves spotted, or blighted when spots become abundant:			
Spots pale green, yellow or brown without concentric markings or definite border; purplish gray below	Leaf spot	*Cercospora concors* (Imperfect fungus)	III, A
Circular or irregular, brown spots with concentric markings, few or becoming very numerous and causing complete blighting.	Early blight	*Alternaria solani* (Imperfect fungus)	III, A
Tops more or less completely blighted (wilt and turn brown):			
Basal portions of stems normal. Young leaves wilt and turn brown; edges only or whole leaflets involved; no fungus:.			
Following period of low temperatures	Frost injury	Frost	Smudging or orchard heaters rarely used
Following period of warm cloudy or rainy weather	Sun scald	Bright sun after hot, humid period	Not generally serious
Following or during a long drought period	Tip burn	Water shortage	VII, B
Leaves show brown, marginal or terminal areas which advance rapidly and show whitish or grayish fungous bloom on under surface	Late blight	*Phytophthora infestans* (Downy mildew)	III, A; XI, A
Basal portion of stem black and rotting; foliage yellowish and leaflets frequently rolled	Black leg	*Bacillus phytophthorus* and other bacteria	XI, A; I, A
Basal portion of stem dry and shriveled; foliage changes as in black leg; brown fungous threads on roots and tubers	Rhizoctonia disease	*Corticium vagum* var. *solani*	See same disease on tubers
Basal portion of stem dry and shriveling; woody ring or fibers blackened; tubers rot or show bundle browning at stem end	Wilt	Fusarium spp. *Verticillium alboatrum* *Bacterium solanacearum*	XI, A; V, N
Tops not generally blighted, but otherwise abnormal:			
Small *slender* sprouts instead of normal vigorous shoots	Spindling sprout	Poor storage or growth conditions	IX, D good ventilation; use northern-grown seed
Leaflets turgid, wrinkled and curled; plants under-sized and tubers few, small.	Curly dwarf	Cause unknown. Hereditary	XI, A d, e or f
Leaflets rolled upward and inward and more or less discolored; (Similar condition may be induced by early stage of black leg, wilt or Rhizoctonia) none to few tubers	Leaf roll	Cause unknown. Hereditary	XI, A d, e or f
Leaflets spotted or mottled with lighter green or even yellowish color; frequently puckered or wrinkled; discolored spots thinner than the normal parts	Mosaic	Cause unknown. Hereditary	XI, A d, e or f

POTATO (Insects). See also leaf-hopper under *apple insects;* grasshoppers, leather jackets, and white grubs under *grain and grass insects;* 12-spotted cucumber beetle under *cucumber insects;* cutworms under *garden insects;* tomato worm under *tomato insects;* carrot-beetle under *carrot insects;* also *general garden insects.*

White or yellowish white grubs tunnel inside the stems.	Potato stalkborer or weevil	*Trichobaris trinotata* (Snout beetle)	V, G (the vines immediately after digging)
Insects attacking the foliage:			
Adult beetles or their grubs feed on the leaves:			
Pale red slugs rapidly increasing in size; adults pale yellow with 10 longitudinal black lines on wing covers.	Colorado potato beetle	*Leptinotarsa decimlineata* (Beetle)	III, K, L or M
Slender beetles with flexible wing-covers and soft bodies ($\frac{1}{2}$–$\frac{3}{4}$ inch):			
Black with 3 distinct longitudinal yellow stripes	Striped blister beetle or "old fashioned" potato beetle	*Epicauta vittata* (Beetle)	III, K, L or M
Slate-gray or shining black	Blister beetle	Species of Meloidae (Beetles)	" "
Slugs covered with mass of their own excrement; adults pale yellow, with three black stripes on its back	Three-lined leaf-beetle	*Lema trilineata* (Beetle)	III, K, L or M
Minute brown or black, jumping beetles ($\frac{1}{20}$–$\frac{1}{12}$ inch) eat small irregular holes (larvae feed on roots).	Flea beetles	*Epitrix cucumeris* and others (Beetles)	III, A (5-5-50) or add K if beetles are abundant
Small green lice sucking juices from leaves and young stems	Potato aphis	*Macrosiphum solanifolii* and others	III, V if severe. V, G (old vines and weeds after digging); VI, C

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Insects attacking the tubers:			
Surface showing irregular, warty protuberances; small darkened specks in flesh just below the surface	Eel worms	*Heterodera radicicola* (Round worms)	VI, F (cereal crop); XI, A
Slender, white or yellowish, shining worms eat irregular holes	Wire worms	*Elateridae* (Various species of click beetles)	VI; A a b; avoid sod crop
White or pinkish, black-headed larvae burrowing within the flesh (about ½ inch); same larvae also attack stems and mine the leaves	Potato worm or tuber moth	*Plathorimaea operculella* (Moth)	VI, J b + hilling IX, A (sack before night) VI, F; IV, B b; V, G
Large holes eaten out or tubers tunneled through, by large cricket-like insects	Mole cricket. Sand or Jerusalem cricket	*Gryllotalpha borealis* Stenopelmatus sp.	X, Ab and clean cultivation. V, N; X, A b

PRUNE. See *plum diseases and insects.*

PUMPKIN (Diseases). See wilt, downy mildew, and powdery mildew under *cucumber diseases.*

PUMPKIN (Insects). See citrus mealy bug under *citrus insects;* corn ear-worm under *corn insects;* flea beetle under *potato insects* and *cucumber and squash insects.*

QUINCE (Diseases). See black rot, black spot canker, fire blight, fruit spot, and ripe or bitter rot under *apple diseases;* leaf blight or spot and rust under *pear diseases.*

Large black knots or swellings on trunk or branches	Black knot, aërial crown gall or hairy root	*Pseudomonas tumefaciens* (Bacterium)	Apparently not injurious

QUINCE (Insects). See various *apple insects* and especially the round-headed borer; also plum curculio and European fruit Lecanium under *plum insects;* cherry scale under *cherry insects;* fruit-tree bark-beetle under *peach insects;* and cottony maple scale under *maple insects.*

Fruits knotty or deformed from effect of feeding punctures, or tunneled by the grub of a brownish-gray snout beetle (¼ inch)	Quince curculio	*Conotrachelus crataegi* (Snout beetle)	V, I (infested fruit 1 month before picking time); X, B f III, K (3–50)

RADISH (Diseases). See club-root under *cabbage diseases;* also damping-off under *seedling diseases.*

White, raised blisters on leaves, later bursting and becoming powdery; flowers and pods often overgrown and distorted	White rust	*Albugo candida* (White rust)	VI, F; XI, A; V, G (by burning)
Leaves show spots yellowish on the upper surface but downy white below	Downy mildew	*Peronospora parasitica* (Downy mildew)	III, A (the seedbed before planting) V, H

RADISH (Insects). See *general garden insects; cabbage insects;* also bean thrips and lima bean symphylid under *bean insects;* seed-corn maggot under *corn insects;* potato flea-beetle under *potato insects;* turnip flea-beetle under *turnip insects;* and serpentine leaf-miner under *cotton insects.*

Whitish or yellowish maggots (¼–⅓ inch) burrow in the fleshy roots killing young plants and making older ones unfit for use	Cabbage maggot Western radish maggot	*Phorbia brassicae* *Phorbia planipalpis* (Flies)	X, D b (around plants); III, P (weak solution); VI, A a b.

RAPE. See *cabbage and radish diseases and insects.*

RASPBERRY (Diseases). See anthracnose (fruits not affected) leaf spot, orange rust, and gray mold under *blackberry diseases.*

Foliage suddenly wilts and affected canes die; affected parts of canes show silvery color and minute, black, fungous fruits	Wilt or cane blight	*Leptosphaeria coniothyrium* (Sac fungus)	V, I (diseased canes) III, A (6-6-50) plus resin sticker with 4-5-50 later when in foliage
Leaves wilt and die, fruit dries up and canes assume a bluish-black coloration and fail to revive	Blue stem, (Black-caps only)	*Acrostalagmus caulophagus* (Imperfect fungus)	None perfected
Brown or bluish-black areas appear on bark in autumn; portion including fruiting spurs frequently killed	Spur blight	*Mycosphaerella rubina*	V, I (badly infested canes); III, A + resin sticker
Small, orange or dark brown, powdery spore dots on under side of leaves; frequently more or less yellowing	Leaf rust	*Phragmidium imitans* (Rust fungus)	No treatment unless severe III, A; V, F
Leaves covered with white powdery coating and sometimes more or less curled	Powdery mildew	Sphærotheca sp. (Powdery Mildew)	None generally required
Irregular, brown enlargements on roots or crown (rarely on canes as in blackberry)	Crown-gall	*Pseudomonas tumefaciens* (Bacterium)	XI, A; rarely severe
Leaves yellowish or mottled with yellow, puckered and curled downward at margins; affected plants frequently undersized	Yellows	Non-parasitic	XI, A; V. H

RASPBERRY (Insects). See leaf-hopper, flat-headed apple-tree borer, fruit-tree leaf-roller, oblique-banded leaf-roller, bud-moth, oyster-shell scale, San José scale, scurfy scale, red spider or two-spotted mite, clover-mite, under *apple insects;* Fullers' rose beetle, rose chafer, rose snout beetle and rose scale under *rose insects;* grape leaf-hopper under *grape insects;* imbricated snout beetle and strawberry root worms under *strawberry insects;* and blue sharpshooter under *hollyhock insects.*

Insects feeding on the leaves or buds:			
Larvæ or caterpillars naked, covered with spine-bearing tubercles, light green ($\frac{3}{4}$ inch when mature)	Raspberry saw-fly	*Monophadnus rubi* (Fly)	Jar off during heat of day; III, W
Larvæ webbing together terminal clusters of leaves:			
Bright green ($\frac{1}{2}$ inch)	Raspberry webworm	*Pamphilius fletcheri* (Saw-fly)	F, I; or III, W
Dark green, pupating within folded or rolled leaf	Raspberry leaf-roller	*Exartema permundanum* (Moth)	III, K (early); V, I later
Small, slightly hairy, light-brown beetles ($\frac{1}{4}$ inch) feed on tender leaves and buds	American raspberry beetle	*Byturus unicolor* (Beetle)	III, K (3 or 4-50); VI, B a (late fall)
Insects feeding on fruit:			
Grayish or yellowish spanworms ($\frac{3}{4}$ inch) decorate themselves with bits of leaves stuck on their spines	Raspberry spanworm	*Synchlora aerata* (Moth)	III, W
Minute black bugs ($\frac{1}{8}$ inch) with white stripe on each side, puncture fruits and give them an unpleasant flavor	The negro-bug	*Corimelaena pulicaria* (Bug)	None perfected
Insects injuring the canes:			
Canes killed or weakened by rows of egg punctures	Tree crickets	Oecanthus spp. (Tree crickets)	V, I (at time of pruning)
Terminal shoots wilt due to girdling from outside about 6 inches from tip; larva tunnels downward through pitch	Raspberry cane borer	*Oberea bimaculata* (Long-horned beetle)	V, I
Shoots wilt due to girdling from inside by larva, generally about half way down cane	Raspberry cane maggot	*Phorbia rubivora* (Fly)	V, I (Cut in May and burn)
Terminal shoots wilt from spiral burrows of small larva working just beneath the bark	Raspberry horn-tail	*Hartigia abdominalia* (Horntail fly)	V, I
Canes killed or weakened by tunnels of a larva in roots, crown, or base of canes	Crown or root-borer	*Bembecia marginata* (Moth)	V, I or IX, F b

RHUBARB (Diseases)

Leaves turn red and die; next season root is dead or produces few small leaves	Blight	Non-parasitic. Unknown	XI, A; divide and reset old plants
Leaves become yellow and wilt; Brown fungous threads on roots	Rhizoctonia disease	*Corticium vagum* var. *solani*	See potato Rhizoctonia
Leaves show circular brown spots sometimes with concentric z[illegible]tion	Leaf spots	Several imperfect fungi	Not generally serious

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
RHUBARB (Insects). See *general garden insects;* black plant-bug under *lettuce insects;* apple leaf-hopper under *apple insects;* flea-beetle and stalkborer under *potato insects.*			
Small metallic green beetles (1/8 inch) or their dull green or black larvae (mature 1/4 inch) feed on leaves	Green dock beet		II, K when larvae first hatch
White, grub-like borer tunnels in leaf and flower stalks; adult a slender snout beetle covered with a rust-colored powder	Rhubarb snout beetle	*Lixus concavus* (Snout beetle)	V, I (all old leaves)
RICE (Diseases)			
Diseases affecting the leaves and heads: Leaves show brown spots with ashen centres; few or blighting whole leaves; grains shriveled or heads poorly filled	Blast or rotten neck	*Piricularia oryzae* (Imperfect fungus)	Use early-maturing varieties; V, M
Diseases affecting the heads or grains: Heads remain straight and green, and do not fill, while normal heads droop	Straight head or blight	Non-parasitic. Poor physical condition of soil	VII. Flood when 8 inches high, barely covering for 6–7 weeks; drain and air for 2–3 weeks; when heads are in the "boot," flood again 3 inches deep for 4–5 weeks
Grains transformed into smut masses; dry, black powder at first enclosed by a grayish membrane which ruptures later	Black smut	*Tilletia horrida* (Smut fungus)	I, A
One to few grains in head enlarged, spherical or nearly so, externally dark powdery green, but white within	Green smut	*Ustilaginoidea virens* (Sac fungus)	Not serious, but control not perfected
RICE (Insects). See *grain and garden insects.*			
Small brown or black snout beetles and their larvæ work in the harvested grain	Rice weevil	*Calandra oryza* (Snout beetle)	IV, B a b; I, G
One or more circular discolored spots on grain (1/16–1/8 inch) sometimes pronounced shrivelling or distortion involving part or all of grain	Brown spot speck or pip	Feeding punctures of various stink-bugs plus saprophytic fungi	Control measures not perfected
ROSE (Diseases). See also fire blight, crown-gall, and winter injury under *apple diseases;* cane blight under *raspberry.*			
Diseases affecting the leaves or succulent canes: White powdery coating and leaves more or less rolled	Powdery mildew	Sphaerotheca spp. (Sac fungus)	III, D, H or I; F if away from painted walls
Leaves showing indefinite yellowish spots above, downy white or purplish below	Downy mildew	*Peronospora sparsa* (Downy mildew)	Ditto
Leaves show pronounced irregular black blotches on upper surface, with much yellowing and defoliation when severe	Blotch or black spot	*Diplocarpon rosae* (Sac fungus)	III, D; V, F (in the fall)
Leaves show irregular, indefinite, gray blotches with minute, black spore-fruits	Leaf spot	*Mycosphaerella rosigena* (Sac fungus)	III, D or F not generally severe
Leaves or petioles showing bright orange or dark spore pustules or aggregates	Rust	Phragmidium spp. (Rust fungi)	V, I; or V, H if severe; V, F and G (fall) III, A (early spring)
Leaves show circular, gray, purple-bordered spots	Leaf spot	*Cercospora rosaeicola* (Imperfect fungus)	III, D or F. Not generally severe
Disease affecting the buds: Buds or partially opened flowers blight, turn brown, and show black seed-like bodies within the discolored mass of petals	Bud or blossom blight	Sclerotinia sp. (Sac fungus)	V, I (blighted buds); V, F and G
Diseases affecting the canes: Canes with purple or brown, purplish-bordered elongated spots frequently involving buds; small dark spore-dots produced from older spots	Cane canker	Coryneum sp. (Imperfect fungus)	V, I suggested. Imperfectly known

Canes show brown dead patches which advance and blight the cane; cottony fungus develops from pieces kept moist.	Die-back	Botrytis spp. (Imperfect fungus)	V, I (severe pruning); VII, A and C; V, F and G
Large, irregular black spore masses break out from the stems, more rarely from the petioles	Stem rust	*Earlea speciosa* (Rust fungus)	V, I (infected canes)

ROSE (Insects). See *greenhouse and garden insects;* also apple leaf-hopper, flat-headed apple-tree borer, fruit-tree leaf roller, oblique-banded leaf-roller under *apple insects;* citrus thrips, orange tortrix and various scales as for *citrus fruits;* raspberry horn-tail under *raspberry insects.*

Beetles feeding on the buds, flowers or leaves:			
Bright red, with head, snout and legs black ($\frac{1}{4}$ inch or less)	Rose snout beetle	*Rhynchites bicolor* (Snout beetle)	X, B f; or III, K if very abundant
Gray to dark brown, with an oblique white stripe on the sides of the wing-covers near the posterior end. (The white legless larvae ($\frac{3}{8}$ inch) feed on roots of rose and other plants)	Fuller's rose beetle	Pantomorus fulleri (Beetle)	III, K (3 or 4–50); VI, B (close and thorough;) X, C a
Black but covered with brown yellowish brown, orange-yellow and olive or pale green scales ($\frac{1}{4}$ to $\frac{1}{3}$ inch)	Beautiful Hoplia	*Hoplia dispar* (Beetle)	III, K; or X, B f
Long-legged, slender, dull greenish or golden yellowish ($\frac{1}{3}$ inch or slightly more); feeding mostly on blossoms	Rose chafer	*Macrodactylus subspinosus* (Beetle)	III, K (5–50 plus 1 gallon molasses); VI, C
Larvæ or caterpillars feeding on foliage:			
Leaves skeletonized	Rose "slugs" American rose slug	*Endelomyia rosae*	III, K or M
Holes eaten in the leaves	Bristly rose slug	*Cladius pectinicornis*	III, Z if few
Large sections eaten out from the edges of the leaves	Coiled rose slug	*Emphytus cinctus* (Sawflies)	
Leaves show small yellow spots ($\frac{1}{16}$ inch) or these become sufficiently abundant to give a sickly yellow color; some leaves may be curled also; minute greenish, yellowish or nearly white insects feed on under surface	Rose leaf hopper	*Empoa rosae* (Leaf hopper)	III, V (1–1500) during nymphal or young stage
Bright green or pinkish plant lice ($\frac{1}{12}$–$\frac{1}{8}$ inch) suck juices from leaves and young twigs	The large rose aphis	*Macrosiphum rosae* (Aphid)	III, V
Yellow or light-green plant lice about half as large as the large rose aphis	Small green rose aphis	*Myzus rosarum* (Aphid)	III, V
Snowy white, or gray, thin, flat, nearly circular scales cover the canes	Rose scale	*Aulacaspis rosae* (Scale insect)	V, I (badly infested canes); III F, N, O or P (winter)

RUTABAGA. See especially root maggots under *radish insects* and *cabbage and turnip diseases and insects;* also *general garden insects.*

RYE (Diseases). See also *scab and the three rusts and powdery mildew of wheat and bacterial blight of oats.*

Black, straight or curved, enlarged, horny bodies replace one or more kernels of a head	Ergot	*Claviceps purpurea* (Sac fungus)	XI, A; IX, A, V, M
Long gray lines on leaf-sheaths, leaves and upper part of culm, becoming black and powdery	Smut or rye smut	*Urocystis occulta* (Smut fungus)	I, A (1–40) VI, F
Leaves or heads blighted or heads poorly filled with shriveled kernels; minute, black spore fruits on affected parts	Anthracnose	*Colletotrichum cereale* (Imperfect fungus)	None perfected

RYE (Insects). See *grain and grass insects;* also oat aphis under *oat insects;* and *wheat insects.*

SALSIFY (Diseases). See also *soft rot of carrot.*

White blister-like pustules on the leaves; burst and become powdery.	White rust	*Albugo tragopogonis* (White rust)	XI, A; VI, F; III, A
Leaves with small brown, scattered spore-dots, covered at first, later open	Rust	*Puccinia tragopogonis* (Rust fungus)	Not serious

SEEDLINGS (Disease)

Seedlings drop over, wilt and die; brown rotted area on stem at about ground level.	Damping-off	Rhizoctonia sp. *Pythium debaryanum* and other soil fungi	II (Suited to location and crop); VI, Ha (air-slaked)

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
SEEDLINGS (Insects). See especially wireworms, under *grain and grass insects;* cutworms under general *garden insects;* flea-beetle under potato and also under *garden insects.*			
SORGHUM (Diseases). See leaf blight and blight (bacterial) under *corn diseases.*			
Entire head transformed into a black, shredded, pulverulent mass	Head smut	*Sphacelotheca reiliana*	I, A or B
Individual kernels transformed into elongated, grayish structures entirely filled with black powder	Kernel smut	*Sphacelotheca sorghi* (Smut fungi)	XI, A; VI, F
Leaves with numerous oval spots ($\frac{1}{16}$–$\frac{1}{4}$ inch) showing pink centres and reddish purple borders	Leaf spot or anthracnose	*Colletotrichum falcatum* and *C. lineola* (Imperfect fungi)	None perfected
SORGHUM (Insects). See *grain and grass insects;* also *corn insects.*			
Minute grubs feed on developing seeds and prevent their formation	Sorghum midge	*Contarinia sorghicola* (Midge)	IX, A and discard as seed crop
SOY BEAN (Diseases). See wilt under *cow-pea and cotton.*			
SPINACH (Diseases)			
Leaf spots pale yellow above, gray to violet and powdery below	Downy mildew	*Peronospora effusa* (Downy mildew)	V, G; VI, F; III, especially for young plants
Pale white spots in leaves, not definitely limited; spores produced within the leaf tissue	White smut	*Entyloma ellisii* (Smut fungus)	Not perfected. V. G; VI, F
Leaf spots brown, circular or subcircular, becoming sooty; few or numerous	Leaf blight	*Heterosporium variable*	V, G. (all dead and discarded leaves) VI, F
Older leaves showing pronounced black mold on indefinite, irregular spots	Black mold	Cladosporium spp.	Ditto; also IX, A
Leaves with leaf spots, producing small, dark, spore-fruits or sparse development of brownish spore tufts	Leaf spots	*Colletotrichum spinaceæ* *Phyllosticta chenopodi* *Cercospora beticola* (Imperfect fungi)	See downy mildew
SPINACH (Insects). See *beet insects;* green peach aphis under *peach insects;* melon aphis under *cantaloupes;* serpentine leaf miner under *cotton insects;* potato flea-beetle under *potato insects.*			
Large, irregular, whitish mines in leaves made by white or yellowish green maggot ($\frac{1}{3}$ inch)	Spinach leaf miner	*Pegomyia vicinia* (Fly)	V, C (lambs' quarters) V; I. When practical
Small beetles ($\frac{1}{3}$ inch) with yellow thorax and shining blue wing-covers make holes in leaves; their grayish larvae also feed on the leaves	Spinach flea-beetle	*Disonycha xanthomelaena* (Beetle)	V, C (Various weeds) III; K for young plants
Beetle of similar size and similar habits but with 3 black dots on thorax	Triangular flea-beetle	*Disonycha triangularis* (Beetle)	" "
SQUASH (Diseases). See downy mildew and leaf spot (Cercospora) under *cucumber diseases;* wilt and anthracnose under *watermelon diseases;* Rhizoctonia disease under *potato and tomato diseases.*			
Blossoms blighted and fruits rotted by fungus producing superficially a copious growth of brown to purplish-black spore-bearing threads	Blossom blight and fruit rot. (Summer squash)	*Choanephora cucurbitarum* (Black mold)	None perfected V, G; V, I
Squashes show rotting spots covered with white, green or black mold	Storage rots	Various fungi	IX, B and D; Ventilate and keep dry
Powdery white coating on leaves and young stems	Powdery mildew	*Erysiphe cichoracearum* (Sac fungus)	III, I

SQUASH (Insects). See also flea-beetle under *potato insects;* melon caterpillar and pickle worm under *cantaloupe insects;* striped and spotted cucumber beetles; corn ear-worm under *corn insects;* two-spotted mites under *greenhouse insects;* Harlequin cabbage bug under *cabbage insects;* and *general garden insects.*

Dark, grayish-brown bugs ($\frac{3}{4}$ inch) work on young plants or young foliage of older plants	Squash bug or "stink bug"	*Anasa tristis* (Bug)	X, Bc (Collect in early morning); V, C (fall)
Robust, white, brown-headed larvæ burrow in leaf stalks or stem and cause wilting .	Squash-vine borer	*Melittia satyriniformis* (Clear-winged moth)	X, Be (early varieties.) V. G. (Burn old vines early in fall); VI, Aab
Beetles or their larvæ feed on the leaves; adult beetle yellowish to brownish ($\frac{1}{3}$ inch) with 7 large black dots in each wing cover; larvæ oval ($\frac{1}{3}$ inch) covered with long branching spines	Squash lady beetle	*Epilachna borealis* (Beetle)	III, K or M
STRAWBERRY (Diseases)			
Diseases affecting the leaves:			
Circular brown or gray, purple-bordered spots; few or coalescing to form large irregular blotches	Leaf spot	*Mycosphaerella fragariae* (Sac fungus) *Ascochyta fragariae* (Imperfect fungus)	V, I (cut and burn tops after harvest) III, A (4–4–50) XI, Bb
V-shaped dead brown spots extending from margin toward the centre.	Leaf blight	Aposphaeria sp. (Imperfect fungus)	" "
Leaves more or less rolled and covered with powdery white coating	Powdery mildew	*Sphaerotheca humuli* (Sac fungus)	III, I
Diseases affecting whole plant:			
Plants normal in fall, dead, or make poor growth in spring (No insect injury to crown or roots)	Winter injury	Low temperatures and unfavorable soil conditions	Protect by mulching; XI, Bb
Plants show reddish leaves turning yellow and brown; white powdery coating on base of leaf stalks following moist periods; brown fungous threads on roots. .	Rhizoctonia disease	*Corticium vagum* var. *solani* (Basidium fungus)	V, N. Do not set on ground infected from a diseased potato crop
Diseases affecting the fruits:			
Fruits show brown rotting areas with white powdery coating during or following moist periods	Rhizoctonia rot	" "	" "
Fruits rot during storage or transit to market; dry slowly developing or rapid soft rots	Rot, dry rots soft rots or leak	Various imperfect fungi. *Rhizopus nigricans*, Botrytes spp. etc.	IX, A, B, and D; also keep dry

STRAWBERRY (Insects). See also corn ear-worm under *corn insects;* Fuller's rose beetle under *rose insects;* grape leaf-hopper under *grape insects;* oblique-banded leaf-roller and flea-beetles under *apple insects;* white fly and two-spotted mite under *greenhouse insects;* pale striped flea-beetle under *garden insects;* negro bug and leaf-roller under *raspberry insects;* rose chafer under *rose insects;* and white grubs under *grain and grass insects.*

Insects attacking the leaves. (See also the strawberry root louse). Larvæ or caterpillars feeding on the leaves:			
Leaflets folded or webbed together; caterpillar greenish brown, feeding first on upper side of leaf and then producing a complete folding	Strawberry leaf roller	*Ancylis comptana* (Moth)	III, K (before leaves are folded); V, M (cut tops after harvest)
Leaflets folded or irregularly drawn together; caterpillars olive green, feeding at first on under side of leaflets and skeletonizing small areas	Obsolete banded leaf-roller	*Archips obsoletana* (Moth)	Ditto but under spray
Larvæ remain naked and eat small holes in the leaves or completely devour them:			
Pale green to grayish yellow, head yellow with 3 large dark spots	Black-marked strawberry slug	*Empria maculata*	III, K (At first) III, W (As fruit ripens)
Deep green, head uniformly yellowish brown	Green strawberry slug	*Empria ignota* (Sawflies)	" "

Prominent Symptoms	Name of Trouble	Cause	Prevention or Control
Beetles eating the leaves:			
(See also root weevil). Minute, green, coppery or blue ([illegible] inch)	Strawberry flea-beetle	*Haltica ignita* (Flea-beetle)	III, A
Snout beetles ([illegible] inch) with wing-covers crossed by two irregular light bands; covered with overlapping scales	Imbricated snout beetle	*Epicærus imbricatus* (Snout beetle)	III, K (2.5 to 4–500). Before fruit ripens
Minute, flat, pale-green, lice-like insects soon settle down and secrete a wax covering, then having the appearance of a scale insect	Strawberry white fly	*Aleyrodes packardi* (White fly)	III, V (Early spray under surfaces)
Insects attacking particularly the buds or fruit:			
Bud pedicels girdled by a small black to reddish brown snout-beetle ($\frac{1}{10}$ inch); bud falls and small maggot develops within	The strawberry weevil	*Anthonomus signatus* (Snout-beetle)	Use imperfect flowered varieties for main crop with every 5th row of perfect flowered forms
Minute, yellowish-brown, slender insects ($\frac{1}{20}$ inch) frequent open flowers, and cause blight of blossoms or undersized, misshapen berries	The strawberry thrips	*Euthrips tritici* (Thrips)	III, V (1–1000) as required by abundance
Large ground-beetles feed first on the seeds of green or ripening fruit, later on the pulp	Ground-beetles	Harpalus spp. (Beetles)	X, A (Pieces of meat rolled in Paris green)
Fruits remain small, hard and dark colored or one-sided or knobbed at the tip. (See also stop-back under peach insects.)	"Buttoning" Tarnished plant bug	*Lygus pratensis* (Bug)	Keep down all weeds in garden and waste places. Control not perfected
Insects attacking roots or crown:			
Grubs (White or pink and [illegible] inch long) feed on fibrous roots cutting them off or barking them; also attack crown; adult weevils ([illegible] inch) brown to black, feed on and rag the foliage	Root weevil or crown girdler	*Otiorhynchus ovatus* (Snout-beetle)	IV, B (soil fumigation under canvas at night); one-crop system V, H (before moths emerge)
Dirty white, brown-headed larvæ ([illegible] inch) burrows in crown and plants wilt, dry up and die	Crown moth	*Sesia rutilans* (Moth)	
Small white, yellow-headed grubs ([illegible] inch) burrow down through crown (1 to 3); adult beetles, chestnut brown ([illegible] inch)	Crown-borer	*Tyloderma fragariae* (Snout beetle)	VI, F (One crop with intervening immune crops like potatoes)
Larvæ long, slender, reddish with brown head (less than [illegible] inch), make mines just within the bark of the crown	Crown-miner	Aristotelia sp. (Moth)	V, H or plow up whole bed
White, strongly curved larvæ ([illegible] inch) feed on roots. (Adult beetles [[illegible] inch] feed on foliage)	Root worms	*Typophorus canellus* *Graphops pubescens* *Colaspis brunnea*	III, K for beetles before fruit begins to ripen. VI, F; V, N
Small dark lice feeding first on the tender aerial parts but soon carried down and established on the roots by the little, brown, cornfield ant; plants killed or vitality lowered	Strawberry root louse	*Aphis forbesi* (Aphid)	XI, A or X, Ib (nicotine) V, N; VI, F; V, M (in spring)
SUGAR-CANE (Diseases)			
Canes when split lengthwise show red streaks or bands extending out from the nodal regions; also in more advanced stages external stem lesions	Red rot	*Colletotrichum falcatum* (Imperfect fungus)	V, I (all diseased material); XI, A
Leaves become yellow and dry up prematurely; dark patches on canes finally show small black papillæ which push out curved spore coils	Rind disease	*Thielaviopsis sacchari* (Sac fungus)	XI, Bb; X, Ib (Dip the cane cuttings in Bordeaux); V, G (in fall)
Canes when split show dark central rotting areas or streaks having the odor of pineapples; cuttings fail, germinate but die later, or produce weak plants	Pineapple disease	*Thielaviopsis ethacetica* (Imperfect fungus)	XI, A; V, G (in fall); control insects
Growth retarded, stools weak; roots rot and white mold appears between cane and lower leaf sheaths; small toadstool fruits produced	Toadstool disease	Marasmius spp. (Basidium fungus)	XI, A; V, G; VI, F; also careful drainage and cultivation
SUGAR-CANE (Insects). See also *corn and sorghum insects.*			
Stalks burrowed into below ground by a robust, black beetle ([illegible] inch)	Sugar-cane beetle	*Ligyrus rugiceps* (Beetle)	VI, Bd + Ib

Large, white, brown-spotted caterpillars bore into stalks, destroying buds or "eyes," and stunting growth.	Sugar-cane borer	*Diatraea saccharalis* (Moth)	V, G (in fall); V, I (suckers from early cuttings)
Stalks, crown, and roots attacked by small insects in white cottony clusters . . .	Sugar-cane mealy-bug	*Pseudococcus calceolariae* (Mealy-bug)	VI, F; X, Ib (Dip cuttings in whale oil soap)

SWEET CORN. See *corn diseases and insects.*

SWEET POTATO (Diseases). See also Texas root-rot of cotton under *cotton diseases.*

Diseases causing spotting and discoloration of the leaves:			
Roundish or angular brown bordered spots ($\frac{1}{8}$–$\frac{1}{2}$ inch) bearing small, back spore-fruits in the lighter-colored centre	Leaf blight	*Phyllosticta batatis*	III, A if it becomes serious
Leaf spots similar to above, but white with brown borders and smaller ($\frac{1}{8}$–$\frac{1}{4}$ inch). .	Leaf spot	*Septoria bataticola* (Imperfect fungi)	" "
Leaf yellowish or yellow spotted above, with white raised blisters becoming powdery on the lower surface.	White rust	*Albugo ipomoez panduranae* (White rust)	" "
Diseases affecting roots, or stems also, while still growing in the field:			
Foliage off-color or yellow, followed by wilting; stems close to hill blackened within; roots also may show blackened ring about $\frac{1}{4}$ inch below the surface.	Wilt, yellows, stem wilt, stem rot or yellow blight	*Fusarium batatatis* and *F. hyperoxysporum* (Imperfect fungi)	XI, A; VI, F; V, G (especially around hot-beds); use soil but once
Dark or nearly black, somewhat sunken, circular spots on the roots; small black spots on stems below ground may enlarge until stem is rotted off. (See also storage troubles).	Black rot, black shank or black root	*Sphaeronema fimbriatum* (Imperfect fungus)	" "
Small brown to black spots on stem near soil line, finally girdling and extending up the stem, and causing wilting and death; minute black spore fruits or specks in the diseased areas.	Foot-rot or die-off	*Plenodomus destruens*	" "
Brown, discolored spots or a uniform rusting of the entire surface of the potato. .	Scurf, soil stain, rust or Jersey mark	*Monilochaetes infuscans*	Ditto and VII, F and VIII, D I, D
Small, dry, dark spots on surface of potatoes, later forming pits due to cracking and dropping out of diseased tissue	Soil rot, pit or pox	*Acrocystis batatas* (Imperfect fungi)	Use methods for wilt
Storage rots or rots developing on roots after removal from ground. (See also black rot and foot rot which continue in storage):			
Soft rot generally beginning at one end and advancing rapidly. Coarse, white mold which turns dark, develops from cut surface under moist conditions. . .	Soft rot or black mold	*Rhizopus nigricans* (Black mold)	IV, A (the storage room) or spray with strong blue stone; IX, B and D (50–55°); V, I (the diseased roots) Keep storage house dry and well ventilated
One or more rings or collars of rotting tissue, soft at first but drying and shrinking later	Ring rot or collar rot	*Rhizopus nigricans* (Black mold)	" "
Firm, brown rot generally beginning at the end; potato becomes dry and hard and surface shows numerous pimple-like spore fruits. (Grows also on stems and vines above ground under field conditions.)	Dry rot	*Diaporthe batatatis* (Sac fungus)	" "
Interior of potato turned into a black, charcoal-like mass	Charcoal rot	*Sclerotium bataticola* (Sterile fungus)	" "
Dark, shriveled, superficial patches bearing black pimple-like spore fruits, but later penetrating the potato and turning the infected tissue jet black	Java black rot	*Diplodia tubericola* (Imperfect fungus)	" "

SWEET POTATO (Insects). See also garden insects and potato flea-beetles under *potato insects.*

Small, white legless grubs ($\frac{1}{4}$ inch) burrow in the stems under ground and penetrate the roots, which they thoroughly riddle	Sweet potato root-borer or weevil	*Cylas formicarius* (Beetle)	V, G (Burn vines, feed potatoes to hogs)
Insects affecting the foliage:			
Brownish black beetles ($\frac{1}{16}$ inch) gouge out narrow lines on both leaf surfaces. . .	Sweet potato flea-beetle	*Chaetoenema confinis* (Flea-beetle)	X, Ib (Arsenate of lead 1–10) before setting out, or III, K

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Broadly oval, flattened, tortoise-shell-like beetles or their "peddler" larvæ eat holes in the leaves.	Tortoise beetles	Coptocyla spp. Cassida spp. *Chelymorpha argus* (Beetle)	" "
Large caterpillars resembling the tobacco worm.	Sweet potato hawk moth	*Macrosila cingulata* (Moth)	X, Fa
Bright green larvæ ($\frac{1}{2}$ inch) with dark median stripe and prominent tubercles	Sweet potato plume moth	*Pterophorus monodactylus* (Moth)	III, K

TEOSINTE. See *corn diseases and insects.*

TOBACCO (Diseases). See root-rot (Thielavia) under *sweet pea diseases;* Rhizoctonia under *beans, potatoes and tomatoes;* and sore-shin under *cotton diseases;* also damping-off under *seedlings.*

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Plants wilt, leaves dry up and stalks die; woody portions of stem, especially lower parts, show black or dark discoloration	Granville wilt or bacterial wilt	*Bacillus solanacearum* (Bacterium)	V, N; VI, F
Leaves yellowish mottled and frequently wrinkled and curled.	Mosaic, calico or frenching	Non-parasitic but infectious	II, (seedbeds); XI. A (discard diseased seedlings) VIII, D; VI, Gc (in excess); V, H; sterilize or clean hands after working with diseased plants
Clusters of small, flowering plants devoid of green color (4–12 inches high) attached to roots of the tobacco plant	Broom-rape	Orobanche sp. (Seed plant)	Pull and destroy the parasites before seeding
Diseases showing a spotting of the foliage:			
Circular brown spots with concentric zonation; when severe may coalesce to form extended areas	Brown spot	Non-parasitic. Unfavorable environmental conditions	Control not perfected
Spots smaller and white.	White rust, white speck or "frog eye"	" "	" "
Brown circular spots ($\frac{1}{16}$–$\frac{1}{8}$ inch); older spots white with dark raised border	Leaf spot	*Cercospora nicotianae* (Imperfect fungus)	III, A
Diseases affecting tobacco in the curing shed:			
Small black spots appear on leaves near midrib but spread and whole leaf may become wet and soft.	Poleburn or pole rot	Bacteria and fungi	Keep temperature 60° or under; humidity; 85% or under
The midribs or "stems" rot instead of drying and molds appear on the surface	Stem rot	Fusarium spp. *Trichothecium roseum, Botrytis longibrachiata* (Imperfect fungi)	" "
Leaves or portions dark brown or black in color instead of the normal chocolate brown	Black rot	*Sterigmatocystis nigra* (Imperfect fungus)	Hold temperature below 68°–70°; or force sweat at 113° or above

TOBACCO (Insects). See wireworm, white grubs, and grasshoppers under *grain and grass insects;* cutworms and root knot under *garden insects;* tomato worm under *tomato insects;* tuber moth and flea-beetle under *potato insects;* corn ear-worm and corn-root web-worm under *corn insects;* celery leaf-tier under *celery insects.*

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Insects injuring the stems. (See also cutworms and corn-root web-worm):			
Bugs ($\frac{1}{2}$ inch) grayish above and yellowish or greenish below; suck juices from base of stem and cause wilting.	The spined tobacco bug	*Euschistus variolarius* (Bug)	X, Fa; V, C (mulleins and thistles)
Insects injuring the "bud:"			
Caterpillars yellowish to brownish with longitudinal gray and white stripes (1$\frac{1}{2}$–2 inches when mature) eat the unrolled leaves; also bore into the seed capsules.	Bud worms	*Heliothis armiger* *Heliothis rhexiae* (Moths)	X, Be (corn). X, Ad (corn meal and Paris green sprinkled on buds)

Insects attacking the leaves:			
Small larvæ make irregular blotch mines leaving only upper and lower epidermis	Tobacco leaf miner or "split worm"	*Gelechia solanella* (Moth)	III, K or M
Large green caterpillars (3-4 inches) with showy V-shaped, white spots along sides	The horn worm or tobacco worm	*Protoparce celeus* (Hawk moth)	X, Fa; III, M or K
Leaves become whitened especially along the veins	Thrips	*Euthrips nicotianae* (Thrips)	III, N or V
Leaves show "shot holes," or small spots eaten part way through; eaten by small, black, jumping beetle	Flea-beetle	*Epitrix parvula* (Flea-beetle)	III, K or M or added to Bordeaux
A small black bug ($\frac{1}{8}$ inch) with long greenish legs, punctures the leaves and causes spots and wilting, browning and cracking	The tobacco suck-fly	*Dicyphus minimus* (Bug)	III, V for young forms
Insects injuring the stored product:			
Small brownish beetles ($\frac{1}{16}$ inch) or their larvæ feed on cured or stored products	The cigarette beetle	*Lasioderma serricorne* (Beetle)	IV, Ba; IV, Da

TOMATO (Diseases). See also downy mildew or late blight, early blight, mosaic and bacterial wilt under *potato diseases;* Southern blight under *pepper diseases.*

Diseases affecting the fruits:			
Sunken, discolored spots bearing minute, black spore-fruits	Anthracnose	*Colletotrichum phomoides* (Imperfect fungus)	III, A; VI, F
A dry, black rot appearing at the blossom end; frequently with concentric zonation; sometimes covered with a black mold	Blossom-end rot or point rot	Non-parasitic	Control not perfected; VII, A or B
Brown discolored or burned spots on exposed side of the fruit	Sunscald	Non-parasitic. High temperature	Difficult; cultivate well to hold moisture
Diseases attacking the leaves:			
Minute brown or grayish spots with darker borders, become very abundant and completely blight the leaves working from below toward the top	Leaf spot	*Septoria lycopersici* Cylindrosporium spp. (Imperfect fungi)	III, A; VI, F
Rusty or cinnamon-brown powdery blotches with more or less yellowing	Leaf mold	*Cladosporium fulvum* (Imperfect fungus)	III, A
Veins and other leaf tissues overgrown causing curling and irregular growth	Œdema	Non-parasitic. Excess of water or too high temperature	VII, A or reduce temperature if under glass
Diseases causing general blighting and death of entire plants:			
Blight advancing from lower leaves toward top. Gradual yellowing and blighting; woody portions of base of stem darkened	Fusarium wilt	Fusarium sp. (Imperfect fungus)	VI, F
No bundle browning; leaves frequently rolled or whole plant showing a rosette type of growth	Rhizoctonia disease, yellows or western blight	*Corticium vagum* var. *solani* (Basidium fungus)	VI, F; Avoid potato ground
Blight beginning at the tips and blighting the tender growth first; dark streaks often show on the stems running down from the blighting leaves	Potash hunger	Lack of sufficient potash in the soil	VI, H. (Potash)
Disease affecting the blossoms:			
Blossoms blight and fall, with failure to set fruit	Shedding of blossoms	Unfavorable conditions	Prevent too rich growth

TOMATO (Insects). See *general garden insects;* also white fly under *greenhouse insects;* corn ear-worm under *corn insects;* green peach aphis under *peach insects;* flea-beetles, Colorado potato beetle, and tuber moth under *potato insects;* horn-worm or tobacco worm under *tobacco insects.*

Worm (1 inch full grown) bores into stems, leaving entrance opening, exit opening and castings; part beyond tunnel frequently wilts	Stalk-borer	*Papaipema nitela* (Moth)	V, I; V, C (burdock and ragweed)
Large light green worms (3-4 inches) with showy oblique white stripes along the sides	Tomato worm	*Protoparce carolina* (Hawk moth)	X, Fa; III, K or M if necessary

TREES, DECIDUOUS (Diseases)

Leaves showing white powdery coating	Powdery mildew	Various species of Erysiphaceae	III, I if severe
Leaves showing brown dead spots, circular or angular and minute fungous fruits on either upper or under surface	Leaf spots	Various imperfect fungi	III, A or F for nursery trees; none necessary for mature trees

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Trunk of tree shows rotting of either heart or sapwood or both and "punks" or bracket fungi appear	Heart rot, sap rot, soft rot, white rot, etc.	Various spore fungi	V, J, K, and L; V, H (with utilization)
Roots of tree rotted without a previous rotting of the trunk; spore fruits may appear around the crown (either toadstool or bracket forms)	Root rots	Various *basidium fungi:* also *Ozonium omnivorum* (Sterile fungus)	V, J (Especially around the crown) V, H
Clusters of green leafy shoots grow out from side of either large or small branches	Mistletoe	Phoradendron spp. (Flowering plants)	X, Fc for shade trees
Branches clothed with compact bunches of small silvery gray narrow-leaved plants	Ball moss	*Tillandsia recurvata* (Flowering, non-parasitic plant)	Scrape off with mistletoe hook
Branches clothed with long festoons of silvery gray, slender plants	Long moss	*Dendropogon usneoides* (Flowering, non-parasitic plant)	Ditto for shade trees

TREES, DECIDUOUS (Insects.) See (under *apple*) canker-worm, fall web-worm, bag or basket worm, forest tent-caterpillar, and tussock moths.

Circular or elongated, flat or convex, variously colored insects, generally closely appressed to twigs or branches (leaves in some cases)	Scale insects	Various species	III, F, N, O, P or Q when injurious IV, Dc
Small soft-bodied, green or black insects on leaves or succulent twigs	Aphids or plant lice	Various species	III, N, O or Q for winter use; III, V for summer
Grubs or beetles tunnel in bark or wood of twigs, branches, trunk or roots	Borers	Various species of beetles and moths	V, H, or I according to need; X, Fb; IV, Bd
Leaf-eating caterpillars:			
Dark brown with sprinkling of orange (1¾ inches long when mature); young feed in colonies spinning a covering web and drawing leaves together to make a nest; adult moth white, with brown hair-tuft at end of abdomen	Brown-tail moth	*Euproctis chrysorhaea* (Moth)	Collect and destroy winter nests; III, K
Brownish-yellow (2-2½ inches when full grown) with double row of colored tubercles on the back and similar ones on the side	Gypsy moth	*Porthetria dispar* (Moth)	X, Fa (Egg masses; kill by treating with penetrating poison; III K (5-50)
Light green and yellow or pink with yellow, green and black stripes (1¼-1¾ in); larvæ makes web in fold, or between two leaves	Omnivorous looper	*Sabulodes caberata*	III K if severe
Ants cut off pieces of leaves and carry to nests; defoliation more or less pronounced	Leaf-cutting ants	Atta spp.	Destroy nests; carbon bisulphide or potassium cyanide 1 oz. to 1 gal. water

TURNIP (Diseases). See black rot and club-root under *cabbage diseases;* downy mildew and white rust under *radish diseases;* powdery mildew under *pea diseases;* Rhizoctonia disease and scab under *potato diseases.* For insects, see *general* and *cabbage insects.*

VETCH (Diseases)

Long, narrow, elliptical spots with dull purple border on leaves, bracts and stems	Spot disease	*Protocoronospora nigricans*	Not serious
Powdery coating on leaves; later an abundance of minute, black spore-fruits	Powdery mildew	Erysiphe spp. (Sac fungi)	IX, A; VI, F

VETCH (Insects). See *alfalfa and pea insects;* especially *alfalfa caterpiller and pea aphis.*

WALNUT (Diseases). See also *trees, deciduous,* for general diseases; also crown gall under *apple diseases.*

Conspicuous brown spots (⅛-¼ inch) cause yellowing and defoliation; minute, dark spore-dots on lower surface	Anthracnose	*Marsonia juglandis* (Imperfect fungus)	III, A or F. for nursery trees; V, F
Black spots on developing nuts or leaves causing premature fall; on twigs or branches causing either blight or cankers	Blight	*Pseudomonas juglandis* (Bacterium)	XI, Ab; III, A (?) Probably not paying practice for bearing orchard
Limbs die back from the ends for varying distances; advancing slowly or killing tree in a single season	Die-back	Unfavorable conditions	V, I; VII, B especially in dry seasons
Spindling shoots with yellow leaves die back; or masses of small yellow shoots	Yellows	Unfavorable conditions, either soil or climate	Not perfected; VII, A if season is dry

WALNUT (Insects). See trees, deciduous, for *general insects;* also leaf-hopper and two-spotted mite under *apple insects;* pear thrips under *pear insects.*

Thickened, felt-like pads on the leaves, producing swellings above and depressions on the lower surface	Erinose or blister blight	*Eriophyes tristriatus* (Mite)	Control measures have not been warranted
Blackish, striped, hairy caterpillars feed on the leaves; have the habit of raising both ends of body when at rest	Walnut caterpillar	*Datana integerrima* (Moth)	V, I (Twigs bearing young colonies); III, (Kerosene when collected to molt); III, K (3–50)

WATERMELON (Diseases). See bacterial wilt under *squash diseases;* Mycosphaerella wilt under *cantaloupe diseases;* downy mildew and leaf spots under *cucumber diseases.*

Leaves droop and wilt and the plant dies; wood at the crown a distinct yellow instead of white as in normal plants	Wilt	*Fusarium vasinfectum* var. *niveum*	VI, F; V, N and O; XI, Bb
All parts attacked but fruit shows characteristic circular, sunken spots, with dark spore-fruits or pinkish spore masses	Anthracnose	*Colletotrichum lagenarium* (Imperfect fungi)	III, A; VI, F; V, G (Including diseased vines and fruit)

WATERMELON (Insects). See *cucumber and squash insects* and *general garden insects.*

WHEAT (Diseases). See anthracnose and ergot under *rye diseases.*

Heads destroyed by transformation into black powdery masses; little but central axis left by harvest time	Loose smut	*Ustilago tritici* (Smut fungus)	XI, Aa; I, F (Soak 5 hours in water then 10 minutes at 128–130° F.)
Heads not destroyed but all or part of the kernels transformed into "smut balls"	Bunt or stinking smut	*Tilletia tritici* *Tilletia foetans* (Smut fungi)	XI, A; I, A, B or C; VI, Ac; VI, Ia or b for winter wheat
Leaves or stems showing orange red or black spore pustules:			
Mostly on stem and leaf sheath; in long, brown or black, powdery streaks	Stem rust or black rust	*Puccinia graminis*	XI, Ba or b; V, B (the barberry)
Mostly on leaf blade and leaf sheath:			
Red rust stage shows as minute lemon-yellow spore dots arranged in streaks or stripes	Yellow or stripe rust	*Puccinia glumarum*	XI, Ba or b
Red rust stage shows as scattered spore-dots, brownish orange and larger than in stripe rust	Orange leaf rust	*Puccinia triticina* (Rust fungi)	XI, Ba or b
Leaves or stems show white or tawny, powdery spots or patches	Powdery mildew	*Erysiphe graminis* (Sac fungus)	Not needed
Yellowish or pinkish incrustations on spikelets, chaff or axis of head; kernels blighted or reduced in size and shriveled	Scab	*Gibberella saubinetii* (Sac fungus)	Not perfected; I, A or B suggested

WHEAT (Insects). See *grain and grass insects;* the tarnished plant bug under *strawberry insects;* red spider under *clover insects;* twelve-spotted cucumber beetle under *corn insects.*

Insects attacking and injuring the maturing heads or kernels:			
Minute reddish maggots burrow into the forming kernels; adult flies two-winged, (⅛ inch) yellow or orange	Wheat midge	*Diplosis tritici* (Fly)	VI, F; VI, Aa; V, M
Kernels destroyed by work of minute eel-worms or nematodes; appear somewhat similar to "smut berries"	Nematodes	*Tylenchus scandens* (Nematode or round worm)	XI, A; I, A a or b; VI, F
Insects working principally on the leaves (also on heads):			
Lice of varying color, green, yellow, reddish or almost black feed first on the leaves and later on the heads	Wheat louse or grain aphis	*Nectarophora avenae* (Aphid)	None perfected. Rely on natural enemies
Caterpillars feeding on the leaves uniform grayish or slaty color above and laterally, but nearly white below	Wheat saw flies	Dolerus spp. (Sawflies)	VI, Aa suggested

PROMINENT SYMPTOMS	NAME OF TROUBLE	CAUSE	PREVENTION OR CONTROL
Black-bodied bug ($\frac{1}{6}$ inch) with white wings, each marked with a small black triangle	Chinch bug	*Blissus leucopterus* (Bug)	X, Cc (to prevent migration to corn)
Insects working principally on or in the stems:			
Maggots work in stems near the ground and either kill or stunt the plants; "flaxseed" stage found in the fall.	Hessian fly	*Cecidomyia destructor* (Fly)	VI, Ib; V, M; X, Be (Strips of wheat seeded in August plowed under later)
Larvæ bore in stems and finally tunnel down to nearly ground level and cut off the straw one-half inch to one inch above ground, and then pass the winter in this basal portion	Wheat saw-fly borers	Cephus spp.	V, M; VI, Aa
Heads mature but become characteristically blanched before the normal heads have ripened; larvae boring in stem light greenish ($\frac{1}{4}$ inch)	"White heads" Wheat-stem maggot	*Meromyza Americana* (Fly)	V, M; also burn the straw stacks
Yellowish or whitish legless grubs ($\frac{1}{6}$ inch) bore in the straw and dwarf the heads:			
Make enlargements or distortions of the stem, surrounding parts being hardened	The joint worm	*Isosoma tritici* (Fly)	V, M or cut low and burn the straw; VI, F
No galls or enlargements made, fewer individuals in a straw	Wheat strawworm	*Isosoma grande* (Fly)	VI, F; V, M

FIG. 556. A few of the crop enemies that are listed in the foregoing pages. Doubtless every farmer knows some of them; may no one be unfortunate enough to know them all! *a* Young grasshoppers; *b* Hessian fly; *c* white grub (larva of Maybeetle); *d* ergot (a fungus) on rye; *e* chinch bug; *f* the remains of a smutted head of oats at harvest time; *g* how it looks when heading out; and *h*, for comparison, a healthy head.

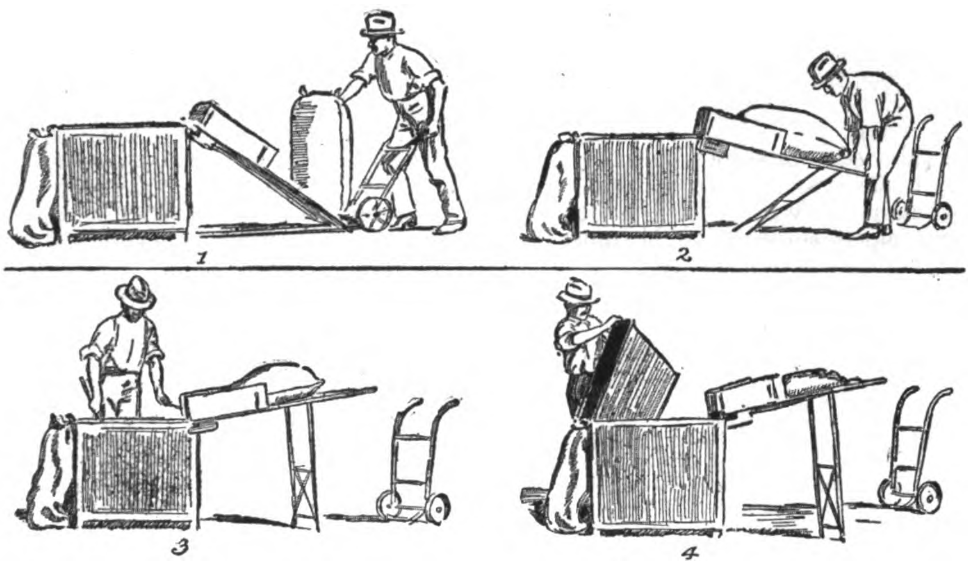


FIG. 557. Handy method for treating large quantities of seed grain: (1) Sack of seed is laid on tray which is then lifted (2) until the grain can trickle into the vat of liquid (3) where it is stirred. When it is thoroughly wet, the hinged drainer in the vat is lifted (4) so that the liquid runs back into the vat and the seed is emptied into the clean bag supported at the end of the device.

CHAPTER 34

Farm Measures for Plant Protection

By PROFESSOR F. D. HEALD (*see Chapter 32*). *Having sketched the general principles of plant injury and its cure and prevention, and having listed (in Chapter 33) the important troubles that affect plants, together with the characters by which they may be identified, we have left only to describe in detail the methods by which we can combat those troubles. While no one farmer will ever be so unfortunate as to have to make use of all these, he will often need to know which one is best, easiest, most effective or cheapest for his particular conditions. Professor Heald has therefore included everything that need be known by the practical farmer in readiness for either defensive or offensive operations.*—EDITOR.

I. Seed Treatment

THE spread of plant diseases through the use of infected seed is becoming more and more evident every year. The term "seed" is used here in a functional rather than in a structural sense, that is, with regard to what purpose it serves, not what it is. Thus a grain of wheat which is a fruit, or a bean which is a true seed, or a seed potato, which is a modified stem, may be infected and serve to spread or start a disease in a new crop. The organism causing the trouble may be in the spore (seed) stage in which case it is generally confined to the surface of the seed; or it may be in the vegetative (growing) form or *mycelium* either on the surface or in the interior. The infections of wheat with bunt or stinking smut come from spores which are lodged in the groove of the grain or entangled in the terminal hairs, while in the loose smut of wheat, the fungus is carried in the form of a dormant mycelium which has penetrated the seed. In the com-

FIG. 558. Seed potatoes can be treated in a wash boiler or feed cooker.

mon scab of potatoes, the organism is superficial (on the surface) while in the late blight, it is internal. The success of a seed treatment depends on the possibility of applying a physical or chemical agent in such a manner as to kill the disease-producing spores or mycelium without seriously lowering the vitality of the seed. Seed infection is, therefore, of such a character in some cases as to make successful treatment impossible. In the use of chemicals, the poisonous substance may be applied in the form of a solution in water ("steep"), or the seed may be subjected to the fumes of a volatile (gaseous) poison as in fumigation.

A. FORMALDEHYDE STEEP. The seed is soaked or dipped in a solution of commercial formaldehyde or formalin (40 per cent solution) in water for a definite length of time. The strength of the solution and the time it is allowed to act on the seed must be given most careful attention. One pint of commercial formaldehyde to 40 gallons of water (a "1 to 40 solution") is a common strength. Formalin solutions lose their strength quite rapidly on standing, so should be used as soon as prepared.

(a) **Sack method.** Sacks of seed may be dipped in a barrel or vat containing the solution, and the surplus liquid allowed to run back.

(b) **Open-tank method.** The seed is emptied into an open tank or vat of the treating solution, and stirred so as to float the smut balls to the surface after which they may be skimmed off.

B. FORMALDEHYDE SPRINKLE. The formaldehyde is sprinkled or sprayed on the grain or seed, which is shoveled over rapidly to distribute the moisture evenly. The grain is then placed in a pile and covered with sacks, canvas or tarpaulin for a time, then spread out to dry.

(a) **Sprinkle**—a 1 to 30 or 1 to 40 solution over the grain until thoroughly wet (about 1 gallon to 1½ bushels). Then cover for 2 to 5 hours before drying.

(b) **Spray.** While shoveling over, spray with formaldehyde (1 pint of the commercial article to 1 pint of water) using 1 quart to 50 bushels of seed; pile and cover for 5 hours. Can plant seed at once.

FIG. 559. Simple farm outfit for treating grain with formalin. Each tub is fitted with a plug and wire strainer. After the smut balls are skimmed off, the liquid is drained off leaving the grain in the tub. (Farmers' Bulletin 507.)

C. COPPER SULPHATE STEEP. The seed is soaked in a solution of copper sulphate or bluestone and water.

(a) **Plain copper sulphate.** The strengths used vary from 1 pound to 4 gallons of water, to 1 pound to 25 gallons, and the time of dipping from momentary immersion to 12 hours. Bluestone treatments generally reduce the per cent of germination to a considerable extent, but this injury may largely be prevented by immersing the seed in lime water (1 pound to 10 gallons) immediately after its removal from the treating solution.

(b) **Copper sulphate and salt.** Use 1 pound of copper sulphate and 1 pound of common salt, to 5 gallons of water. Allow seed to remain in solution for 10 minutes.

D. MERCURIC CHLORIDE STEEP. This (also called the corrosive sublimate method) treatment should be used only when A, B, or C are inefficient since this fungicide is much more expensive and a deadly poison. One or 2 parts to 1,000 of water, or 4 to 8 ounces to 30 gallons may be employed. Seed is generally treated with the solution at ordinary temperature, but in certain cases the effectiveness of the solution may be increased by applying it hot. The following special points should be kept in mind: (1) Use a wooden vessel as the solution will corrode metal. (2) Use a new solution after treating 5 or 6 lots of seed since the fungicidal value of the solution weakens rapidly (It does not, however, lose strength by standing if not used). (3) *Corrosive sublimate is a deadly internal poison* but it is not injurious to the skin and hence may be handled without danger. (4) *Seed so treated should never be eaten or fed to animals.*

E. FORMALDEHYDE FUMIGATION. The seed should be spread in thin layers or in slatted crates. In the case of root crops proceed as follows:

(1) Close all windows and other openings as nearly air-tight as possible and sprinkle the floors and walls with water.

(2) Generate the formaldehyde gas by pouring commercial formaldehyde or potassium permanganate in a tub or

pan at the rate of 3 pints formaldehyde (40 per cent solution) potassium permanganate, 23 ounces for each 1,000 cubic feet of space.

(3) Leave the room at once and keep it tightly closed for 24 hours or longer. Formaldehyde fumigation of seed is not very generally practised; it is likely to cause more or less injury in the case of potatoes. It is, however, a satisfactory method for the sterilization of storage cellars. (See also carbon bisulphide and hydrocyanic and gas treatment, under fumigation.)

F. HOT WATER. This treatment is rather cumbersome and is recommended only for diseases in which there is an internal infection which cannot be reached by any of the chemical treatments. It is to be employed for the loose smuts of wheat and barley. Proceed as follows:

(1) Soak the seed in cold water for 4 to 12 hours (this may be omitted in the case of a disease originating from spores on the surface); (2) drain; (3) dip in a warming bath for 1 minute (temperature nearly that used in final treatment); (4) dip in hot water of the desired temperature; (5) drain and dry or plant at once.

In this treatment, the seed should be placed in a sack or in a wire basket of convenient size and the hot-water baths should have twice the volume of the seed which is to be dipped. The temperatures employed vary from 125 to 133 degrees F. and the time of treatment from 5 to 15 minutes as directed in the discussion of the different diseases.

FIG. 560. In the sprinkle method, moisten all the seed, mix it thoroughly, and leave it covered with meal sacks for several hours as shown in the inset.

G. HOT AIR. Hot-air treatment of cereals for smuts and of potatoes infected with late blight is effective. Heating by steam to 118-125 degrees F. for several hours controls insects in stored grain and manufactured grain products.

II. Soil Sterilization

Certain fungi causing disease in plants live in the soil and enter the host plant through the root system or penetrate the stem at or near the ground level. Many of these attack plants grown on an extensive scale on the field, in which case soil sterilization is out of the question. It is in the seed or cutting beds in the open or in greenhouses that this method finds its widest application. The quantity of soil to be handled in such cases is small, and the treatment can be given without undue expense. All organisms present in a soil are not killed by the treatments recommended so that we do not have an absolute sterilization; the treatment is rather a disinfection which kills the objectionable forms.

A. SURFACE FIRING.

(a) Direct firing. In this method a layer of straw, brush, or other litter is spread over the seedbeds in the open and burned. In carrying out this treatment, the seedbeds should be prepared for planting before burning the litter, after which the ashes may be raked into the surface soil. The ground is then ready for planting, and the upper layers should be free from objectionable organisms.

FIG. 561. These tobacco plants were set out on clean soil. Those in rows *a* and *c* came from seedbeds infected with root rot; those in rows *b* and *d* from "healthy" seedbeds. It pays to renew or sterilize the soil in seedbeds frequently. (Wis. Bulletin 277.)

(b) Pan firing. For this method, a sheet-iron pan, 3 by 9 feet, is employed. Support it over the bed to be sterilized and build a fire beneath. Next shovel the surface 6 inches of soil from the next 3 x 9 foot strip into the pan and heat for an hour. Return this soil to its original position and treat a similar area from the other side of the pan. Next move the pan to the middle of another nine-foot bed and continue the process until the entire area is sterilized.

B. STEAM STERILIZATION. Is adapted for greenhouse work or for beds in the open when live steam is available.

(a) **The perforated-pipe method.** Permanent or movable perforated pipes may be arranged in greenhouse benches. A 2-inch main from a boiler furnishing 80 to 100 pounds pressure should be connected to a set of 1½-inch pipes placed at a depth of 1 foot, spaced 12 to 18 inches apart and provided with one eighth to one fourth inch perforations every 6 to 12 inches. The initial cost of permanent pipes is high, but their operation requires little labor and they may be used for subirrigation if desired. Movable pipes are well adapted to greenhouse work, and the initial expense is much less. If they are employed, 2 sets should be available in order to economize time. These should be 30 feet or less in length and of a width to fit the greenhouse benches. Place the pipe in position and fill in the soil and fertilizer (except commercial fertilizer) and have the seedbed prepared as if for planting. Cover with canvas or tarpaulin and turn on the live steam for 1 to 2 hours.

(b) **The inverted-pan method.** This has proved practical for extensive work in the open and has been successfully employed for the treatment of tobacco seedbeds. The apparatus consists of a sharp-edged, galvanized iron pan 6 by 10 feet and 6 inches deep, fitted with handles for convenience in moving, and provided with an intake for the attachment of a steel hose. In practice the pan is inverted over the soil to be sterilized and the edges forced into the ground to prevent the escape of steam which is then turned in. The temperature is maintained at 175 to 180 degrees F. for 1 to 2 hours. Successive areas may be treated in this way until the entire seedbed has been covered. In sterilizing seedbeds by steam, it should be borne in mind that lighter soils are more easily sterilized than heavy ones. Also that soils high in humus are liable to injury by over sterilization. Soils can be most efficiently sterilized when they contain a medium amount of water.

Fig. 562. A few garden plants can often be protected by a dust spray applied by means of a pepper box

C. APPLICATION OF A FUNGICIDE. This may be distributed (in solution) from a sprinkling can, a spray pump, or by one of the overhead watering systems. In all cases the ground should be spaded or plowed and put into shape for planting previous to the application of the fungicide.

(a) **Drenching with formaldehyde.** Apply a solution of commercial formaldehyde, 3 pints to 50 gallons of water, at the rate of seven eighths gallon to 9 square feet, cover with canvas for 24 hours and air for 1 week before seeding. Ground intended for early spring planting may be sterilized in the late fall if more convenient.

(b) **Sulphuric acid drench.** Apply three sixteenths ounce of commercial sulphuric acid (in water) per square foot of soil at the time of seeding. Possible injury to seedlings may be greatly reduced by abundant watering during the germination period. This method is especially applicable to the treatment of seedbeds used for growing pines or other evergreens.

(c) **Sulphur.** Flowers of sulphur or sulphur flour may be broadcasted and then worked into the surface soil just before planting at the rate of 350 to 900 pounds per acre. This soil treatment is of particular value in treating land badly infected with the organisms causing potato scab.

III. Spraying

Either fungicides or insecticides may be used alone or mixed, and sprayed upon plants at a single operation. Some insecticides and fungicides may be mixed without in any way impairing their efficiency, while others are incompatible, that is, should not be mixed. In the following table "x" indicates that there is but slight chemical reaction and the sprays may be safely mixed; "o" indicates that

there is a reaction which harms or destroys the value of the individual sprays; "r" indicates that the mixture is repellant to the taste of chewing insects, and hence the combination is not apt to be so effective as if the arsenical were used alone; "s" indicates that the combination might scorch foliage; "u" indicates that the mixing is unnecessary.

	LIME SULPHUR	BORDEAUX	LEAD ARSENATE	NICOTINE	SOAP	LIME	SODA SULPHUR	OIL EMULSION	IRON SULPHIDE	ATOMIC SULPHUR
Lime-sulphur	..	o	xrs	x	o	u	u	o	u	u
Bordeaux	o	..	xr	x	ox	u	o	o	u	u
Lead arsenate	xrs	xr	..	xr	s	ur	os	xrs	x	x
Nicotine	x	x	xr	..	x	u	o	x	x	x
Soap	o	ox	s	x	..	o	xu	xu	x	x
Lime	u	u	ur	u	o	..	uo	o	u	u
Soda-sulphur	uo	o	os	o	xu	o	..	x	xu	u
Oil-emulsion	o	o	xrs	x	xu	o	x	..	x	x
Iron sulphide	xu	xu	u	x	x	u	xu	x	..	u
Atomic sulphur	ux	u	x	x	x	xu	xu	x	u	..

(From Popular Bulletin 100, Wash. Agr. Exp. Sta. 1916)

A. BORDEAUX MIXTURE

Copper sulphate (bluestone) . . 4 pounds
Quicklime . . . . 5 pounds
Water . . . . 50 gallons

Prepare stock solutions of both the copper sulphate and the lime of such strengths that each gallon will contain 1 or 2 pounds of one or the other of these substances. Protect from evaporation or dilution by rains, and always stir before using. Dissolve copper sulphate either by suspending it in a coarse bag in the water or by using hot water.

In using the stock solutions, measure out the right amount of each to give the desired number of pounds of chemical and dilute with half the quantity of water in separate (wooden) vessels. The two diluted solutions should then be poured together through a copper sieve (about 20 meshes to the inch) to exclude small solid particles. Bordeaux should always be freshly made each time, as it becomes weak on standing. The mixture may be tested to see that it does not contain an excess of copper by adding a few drops of a 10 per cent solution of potassium ferro-cyanide (yellow prussiate of potash). If the drops make a brown sediment appear in the Bordeaux, more lime should be added.

Other strengths of Bordeaux mixtures are:

	(a)	(b)	(c)	(d)	(e)
Copper sulphate	1 lb.	2 lbs.	2 lbs.	3 lbs.	6 lbs.
Lime	2 lb.	2 lbs.	4 lbs.	4 lbs.	6 lbs.
Water	50 gal.	50 gal.	50 gal.	50 gal.	50 gal.

(From Popular Bulletin 100, Wash. Agr. Exp. Sta.)

The dilute mixtures up to the 2-4-50 formula are designed for summer sprays on plants like peach and Japanese plums which have tender foliage.

B. RESIN BORDEAUX

Bordeaux, any strength . . 48 gallons
Resin "sticker" . . . . . 2 gallons

The resin "sticker" is made by melting 5 pounds resin with 1 pint fish oil, cooling slightly and adding 1 pound soda lye while stirring. The mixture should be diluted with 5 gallons of water. The "sticker" makes the Bordeaux stick better and is needed in spraying plants having a very smooth surface.

C. BURGUNDY MIXTURE

Copper sulphate . . . . 2 pounds
Sodium carbonate (sal soda) . 3 pounds
Water . . . . 100 gallons

Each of the ingredients should be dissolved separately in water and then diluted to make half of the quantity to be used and the 2 diluted solutions brought together as in mixing Bordeaux. This mixture may be used to advantage when it is necessary to avoid the spotting of developing fruit by Bordeaux.

D. AMMONIATED COPPER CARBONATE

Copper carbonate . . . . 5 ounces
Ammonia (26 degrees Beaume) 3 pints
Water . . . . 50 gallons

Dilute the ammonia with about 12 pints of water and use just enough to dissolve the copper carbonate. The strong solution may then be diluted to the proper volume. It should be used very soon after preparation. It is not as good as Bordeaux but may be used when the sediment or stains from that fungicide are objectionable, for example, in late sprayings of small fruits.

E. IRON SULPHIDE MIXTURE

Iron sulphate (copperas) . . 4 pounds
Lime-sulphur (33 degrees Beaume) 1 gallon
Water . . . . 200 gallons

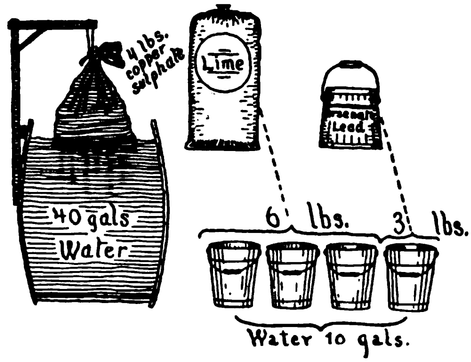


FIG. 563. An all-round spray for fungous diseases and chewing insects is Bordeaux mixture (4-6-50 here) with 3 pounds of arsenate of lead added to each 50 gallons. Dissolve the copper sulphate by suspending it in the water, not by putting the bag in the bottom of the barrel. (O. Bulletin 217.)

A stock solution of iron sulphate should be made, using 1 pound to the gallon. Fill the sprayer tank and when the agitator is running, add the lime-sulphur; then slowly pour in the right amount of iron sulphate. In order to insure complete precipitation of the iron sulphide, a slight excess of lime-sulphur may be used. Iron sulphide is a mildew spray and has been recommended especially for apple mildew. It has not been very generally tested for other mildews.

F. LIME-SULPHUR. Home-boiled or factory-boiled or commercial lime-sulphur is an insecticide as well as a fungicide. It is very extensively used in place of Bordeaux for fungous diseases since it is less likely to cause burning or russeting. The home-boiled article may be made according to the following formula:

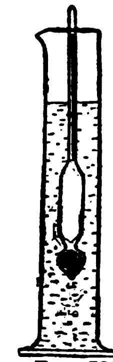


FIG. 564. Hydrometer for testing lime-sulphur

Sulphur . . . 1 to 1¼ pounds
Fresh stone lime. ½ pound
Water . . . . ¾ gallon

(1) Slake the lime in the cooker. (2) Add the sulphur and the water. (3) Boil briskly till the sulphur is dissolved (about 45 minutes) stirring continuously and keeping the cooker covered; as it boils down keep adding water. (4) When finished let settle. (5) Use only the clear liquid, which may be stored if kept from the air. Prepared in this way lime-sulphur should give a hydrometer reading of about 26 degrees Beaumé, somewhat weaker than the factory-made product.

Any concentrated lime-sulphur may be diluted for use as follows:

HYDROMETER TEST OF CONCENTRATE		TO MAKE 100 GALLONS OF SPRAY USE:				
		FOR DORMANT SPRAY	FOR SUMMER SPRAY 1	FOR SUMMER SPRAY 2	FOR SUMMER SPRAY 3	FOR SUMMER SPRAY 4
Beaumé Degrees	Specific Gravity	1 (pound sulphur) to 5 (gallons) Beaumé 3° Sp. gr. 1.020	1 to 25 Beaumé 1.6° Sp. gr. 1.011	1 to 30 Beaumé 1.28° Sp. gr. 1.0094	1 to 40 Beaumé 1° Sp. gr. 1.0071	1 to 50 Beaumé 0.82° Sp. gr. 1.0057
		GALLONS	GALLONS	GALLONS	GALLONS	GALLONS
34	1.3015	6.7	3.6	3.1	2.3	1.9
33	1.2901	6.9	3.8	3.2	2.4	2.0
32	1.2788	7.2	4.0	3.4	2.5	2.0
31	1.2677	7.5	4.2	3.5	2.6	2.1
30	1.2569	7.8	4.4	3.7	2.7	2.2
29	1.2462	8.2	4.6	3.8	2.9	2.3
28	1.2357	8.5	4.8	4.0	3.0	2.4
27	1.2254	9.0	5.0	4.1	3.1	2.5
26	1.2153	9.4	5.2	4.3	3.3	2.6
25	1.2053	9.8	5.4	4.6	3.4	2.8
24	1.9155	10.2	5.7	4.8	3.6	2.9
20	1.1578	12.3	7.1	6.3	4.5	3.6
16	1.1224	16.2	9.5	7.6	5.7	4.7

For example: To make summer spray No. 2 from 33° lime-sulphur, use 3.2 gallons concentrate to the 100-gallon tank, that is 1 to 30 of water. (From Popular Bulletin 100, Wash. Agr. Exp. Sta., 1916)

G. LIME-SULPHUR, SELF-BOILED

Lime . . . . 8 or 10 pounds
Sulphur . . . . . 8 or 10 pounds
Water . . . . 50 gallons

These are known as the 8-8-50 and the 10-10-50 formulae. The spray can be used on trees like the peach, with tender foliage, without danger of burning, or on apples with little danger of russeting the fruit. However, none of the lime-sulphur sprays has as high a fungicidal value as Bordeaux except in the treatment of mildews.

The following method of preparation is taken from Bulletin 174 of the Bureau of Plant Industry, Department of Agriculture of the United States.

The mixture is composed of 8 pounds of fresh stone lime and 8 pounds of sulphur (either flowers or flour may be used), to 50 gallons of water. It can best be prepared in

rather large quantities say, 32 pounds of lime and 32 pounds of sulphur, to be cooked with a small quantity of water (8 or 10 gallons) and then diluted to 200 gallons.

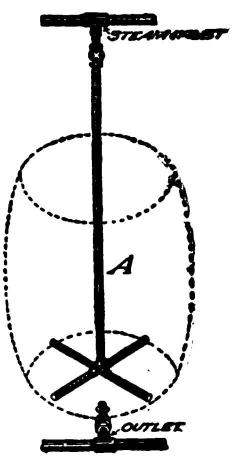
The lime should be placed in a barrel and enough water poured on to almost cover it. As soon as the lime begins to slake, the sulphur should be added after first running it through a sieve to break up the lumps. The mixture should be constantly stirred and more water added as needed to form a thick paste at first and then gradually a thin paste. The lime will supply enough heat to boil the mixture several minutes. As soon as it is well slaked, water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted and applied.

H. POTASSIUM SULPHIDE

Potassium sulphide . . .	3 to 5 ounces
Water	10 gallons

This has been quite generally used for gooseberry and other mildews. It is not as effective as lime-sulphur, but may be used if lime-sulphur shows any injurious effects.

I. SULPHUR. Flowers of sulphur or any brand of finely sub-limed sulphur may be used as a dust spray. Sulphur dust has been recommended especially for grape powdery mildew, and may be tried for other powdery mildews also. It is effective for asparagus rust, and has recently been used with fair success in treatment of fungous diseases of apples and nursery stock.



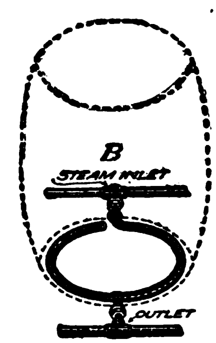


FIG. 565. Two simple piping arrangements for steam cooking lime-sulphur in an ordinary barrel

There are various commercial forms of sulphur such as "atomic sulphur," "sulphur paste" etc., which may be used as liquid sprays at the rate of 2 to 6 pounds to 50 gallons of water. These are valuable in mildew control.

J. WHITE ARSENIC. This is the cheapest form in which arsenic can be obtained, but it is very injurious to foliage since it is soluble in water.

(a) For use with Bordeaux mixture only:

2 lbs. Sal soda
1 lb. White arsenic
1 gal. Water

Make a paste of the arsenic, add the sal soda and more water and boil until dissolved, adding water to make 1 gallon of stock solution. Use 1 quart to 50 gallons of Bordeaux.

FIG. 566. Cooking lime-sulphur with steam (see Fig. 565)

(b) For use without Bordeaux:

1 lb.	Sal soda
2 lbs.	Quicklime
1 lb.	White arsenic
1 gallon . . .	Water

Dissolve the sal soda and white arsenic as above and use the hot solution to slake the 2 pounds of lime. Dilute to make 2 gallons. Use 2 quarts to 50 gallons of water.

K. ARSENATE OF LEAD

Arsenate of lead paste	1–2 pound
Water	40–50 gallons

For newly-hatched insects, it is not necessary to use it stronger than 1–50. For old or large insects, use 2 pounds to 50 gallons. Some more resistant forms may require 3 to 5 pounds to 50 gallons. First mix the paste with a small quantity of water, then dilute to the desired volume.

Powdered arsenate of lead is about twice as strong as the paste, so 1 pound to 50 gallons is generally sufficient.

L. ZINC ARSENITE. This is a white, fluffy powder that kills insects somewhat more quickly than lead arsenate for which it may be substituted. It may be combined with either Bordeaux or lime and in such form is fairly safe on apple foliage. One pound is equal in effectiveness to about 3 pounds of lead arsenate.

M. PARIS-GREEN. The important compound in this insecticide is arsenious oxide and the commercial grades vary in strength. According to the Federal Insecticide Law, the standard is not less than 50 per cent of arsenious oxid, and arsenic in water-soluble form must not be present to the equivalent of more than 3½ per cent of arsenious oxid.

Paris-green was for many years the standard arsenical, but on account of its scorching effect on foliage, it has been very largely replaced by arsenate of lead, especially for orchard work. It may be applied either wet or dry. Mixing with Bordeaux, lime,

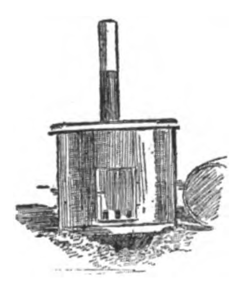


FIG. 567. Farm cooker for boiling lime-sulphur

or an inert substance lessens the danger of foliage injury.

(a) Dry or as dust spray:

1 lb. . . . . . Paris-green
25-50 lbs. Air-slaked lime, gypsum, or flour.

(b) Wet or as liquid spray:

1 lb. . . . . Paris-green
2 lbs. . . . . Fresh stone lime
100–150 gallons . Water

London purple, an arsenite of lime, was formerly used. Its arsenic content is more variable; it is liable to burn foliage, and consequently it has fallen into disuse.

N. KEROSENE EMULSION. This contact insecticide may be prepared as follows:

½ lb. Fish-oil soap (or 1 lb. laundry soap)
2 gallons . . . Kerosene
1 gallon . . . Water

Dissolve the soap in hot water, remove from fire and add the kerosene. Churn or pump mixture until creamy. Dilute as follows:

(a) Dormant spray: 1 part to 5 to 7 parts water.

(b) Summer spray: 1 part to 10 to 15 parts water.

Foliage injury is likely in many crops and consequently tobacco preparations have come **into more general use for plant lice. Crude oil may be used in the place of kerosene.**

O. DISTILLATE EMULSION

20 gallons Distillate (28 degrees Beaumé)
30 lbs. . . . . Whale-oil soap
12 gallons . . . Water

Dissolve soap in water and boil. Add distillate and mix thoroughly while hot. For use add 1 gallon of stock to 20 gallons of water.

P. CARBOLIC ACID EMULSION

40 lbs. . . . Whale-oil soap
5 lbs. . . . Crude carbolic acid
40 gallons . . Water

Dissolve soap in hot water, add the carbolic acid and boil for 20 minutes. For use add 1 gallon of the stock to 20 gallons of water.

Q. MISCIBLE OILS. These are proprietary sprays, and are concentrated oil emulsions intended primarily for use against San Jose scale. The dilution is 1 gallon to from 15 to 17 gallons of water.

R. COMMON SOAP. Soap and water may be used as a spray for certain soft-bodied insects such as lice and red spider.

Dissolve 1 pound laundry soap in 8 gallons hot water and dilute to requisite volume.

S. WHALE-OIL SOAP. This is more effective than ordinary soap. An excellent article may be prepared as follows:

6 lbs. . . . Caustic soda
22 lbs. . . . Fish-oil
½ gallon . . Water

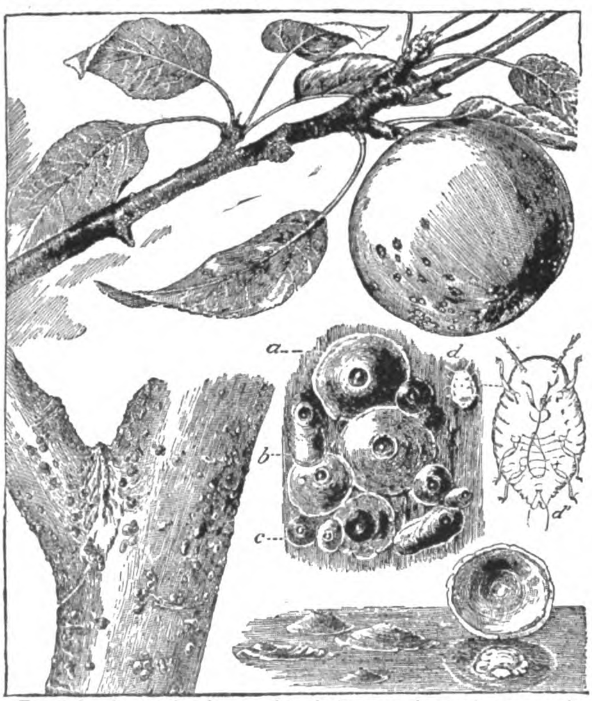


FIG. 568. San José scale, one of the fruit growers' worst insect enemies. Branch and fruit show general appearance. *a* Mature female, *b* male, *c* young scale; *d* young larva; at bottom scale lifted to show female body; all much enlarged. (Farmers' Bulletin 650).

Dissolve the caustic soda in the water, then add the fish-oil very gradually while stirring constantly and vigorously. Boiling is unnecessary, but the mixture should be stirred for about 20 minutes after the oil has been added.

T. TOBACCO POWDER. Finely ground tobacco may be used in greenhouse work, especially for plant lice, as a dust spray.

U. TOBACCO DECOCTION. This may be used for plant lice in greenhouse work.

Boil 1 pound tobacco stems in 2 gallons water for half an hour; strain and dilute to 2 gallons.

V. NICOTINE. Use of "Black leaf 40" or other 40-per cent nicotine preparation, 1 gallon; of water, 800–1,600 gals.

Add 4 pounds of soap for each 100 gallons of spray. Dissolve the soap in hot water and add to the mixture to make it spread and stick better. When used with lime-sulphur, the soap may be omitted. In some cases a stronger mixture is required, as for the chrysanthemum leaf miner against which 1 part to 200-400 has been effective.

W. HELLEBORE. This is a vegetable powder made from

the roots of the hellebore plant. It is less poisonous than the arsenicals, and may be used with safety on ripening fruits. It soon loses its strength so the fresh article should always be used.

(a) **Dry or powder:** Do not dilute; or add a little flour to make it stick.

(b) **Wet or liquid:** Use 4 ounces hellebore powder; 1 ounce glue or flour paste; 2 to 3 gallons water,

X. DUST REPELLANTS. Certain small or soft-bodied insects may be controlled by the use of inert dust repellants. Thus flour, air-slaked lime, limoid, gypsum, etc., may be sprinkled on the plants. Such treatment is employed with success in early attacks upon seedlings in the garden.

Y. LYE. A concentrated solution of lye may sometimes be used for cleaning lichens and mosses from the trunk and branches of trees, but it should be used as a dormant spray only. It may be employed as follows: 6 to 8 pounds (cans) concentrated lye; 50 gallons water.

Z. WATER ONLY. In certain cases insect pests such as garden slugs may be controlled by a thorough drenching with the garden hose. The force of the spray knocks many insects to the ground; many others will be killed by repeated drenchings.

FIG. 569. One of the climbing cutworms attacking carnation buds.

IV. Fumigation

In fumigation, the insecticides or fungicides are used in gaseous form for the treatment either of seed or of crop plants.

A. FORMALDEHYDE. See Seed Treatment I, E, (p. 503).

B. CARBON BISULPHIDE. Special precautions to be observed in using this gas are: (1) It is inflammable. Hence lamps, electric lights, or fans, pipes or cigars, or hot steam-pipes might cause a fire. (2) Notify owners of adjacent buildings before starting a general fumigation.

(a) **For weevils in beans, cereals, etc.** Put seed into closed receptacle and subject to fumes, using 1 ounce to each 12 cubic feet of air space. Place the carbon bisulphide above the seed to be treated as the gas is heavier than air.

(b) **For storehouse fumigation.** (1) See that the room or bin is as tight as possible. (2) A temperature of 70 degrees or above is essential to success. (3) Use 1 to 5 pounds of carbon bisulphide to every 1,000 cubic feet, if the compartment is air-tight. If not air-tight, increase the amount. Place the liquid on top of the seed in shallow vessels.

(c) **For root pests.** Make one or more small holes in the ground near the base of the plant, the number depending on the size of the plant; pour the liquid into the holes; and close them to prevent evaporation. A syringe-like apparatus may be used to inject the liquid.

(d) **For wood borers.** The liquid may be injected into the tunnels or burrows of wood or bark-boring insects. The operation is expensive and only partially effective since the pests have frequently disappeared before the burrows become evident at the surface.

C. TOBACCO. Tobacco fumes may be used in the control of plant lice, thrips, mites, etc., on house or greenhouse plants. Foliage injury of tender plants may be avoided by burning the tobacco slowly or by the use of one of the several proprietary, volatile tobacco products now on the market.

D. HYDROCYANIC ACID GAS. This is a *deadly poison* produced by the action of sulphuric acid to which water has been added, on either potassium or sodium cyanide. It may be prepared as follows:

(1) Measure the acid in glass or earthenware and put into an earthenware crock or jar to be used as the generator. (2) Measure out the requisite amount of water and pour into the acid. (Or better, pour the acid *slowly* into the water to prevent the spattering that might otherwise ensue.) (3) Place the generator in the box, room, greenhouse, or tent to be fumigated. (4) Drop the measured amount of cyanide into the generator, (bag and all, if in paper) and close or leave the fumigation chamber at once. Remember the deadly character of the fumes, and get away immediately so as to take no chance of inhaling any. (5) Leave the fumigation chamber closed the required length of time, and do not enter it until at least 10 minutes after all the doors or ventilators have been opened.

The gas is lighter than air; hence the generator should be placed either below or as low as any of the articles to be fumigated. The exact proportions of the chemicals to use are:

1 oz. Potassium cyanide (98 to 99 per cent)
1 fluid oz. Sulphuric acid (66 degrees Beaumé)
3 fluid ozs. . . . . . Water

or
- 1 oz. Sodium cyanide (129 to 130 per cent
- 1½ fluid ozs. Sulphuric acid (66 degrees Beaume)
- 2 fluid ozs. . . . . Water

(a) **For granaries, mills, storehouses or elevators.** Use the 0.25-gram formula of potassium cyanide or 0.17 gram of sodium cyanide to each cubic foot of space. Compute the cubic contents of the room and use the following formula:

Cubic feet in room x (0.25 or 0.17) ÷ 28.35 = ounces of cyanide to use. Calculate the amount of acid and water from the proportions given above.

Use bags containing only up to 3 pounds of cyanide, and a separate generator for each lot. Distribute these about the room, and arrange cords run through heavy screw eyes so that all the bags of cyanide may be dropped into the generators at once from a door or stairway leading out of the room.

Allow the gas to act for 6 to 24 hours before opening the room or building. Take precautions to prevent any one from entering before the rooms have been thoroughly aired.

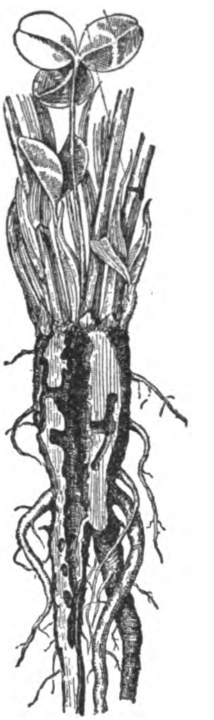


FIG. 570. Work of the clover root borer. (Farmers' Bulletin 455)

(b) **For greenhouses or cold frames.** Use 0.05 to 0.15 gram of potassium cyanide to each cubic foot of space (⅓ less if sodium cyanide is used). The strength and time of exposure must vary in accordance with the kind of plants to be fumigated. The danger of burning the foliage is one of the difficulties that attend the use of cyanide fumigation. Compute the amount of cyanide required as directed in D a. Roses and chrysanthemums are very sensitive and are injured some even by the smallest doses. The list at the top of the next column will assist in determining the time and strength of the gas.

Young seedlings of any kind are much more sensitive than mature plants. A small house will require only a single generator; larger ones will need several arranged as advised above.

(c) **For nursery stock.** In many states, cyanide fumigation of all nursery stock is required previous to shipment. For this work special fumigation boxes, chambers or buildings of varying capacity must be constructed. For general nursery stock, employ the 0.25

	GRAMS	TIME
Delicate Ferns . . .	0.075	20 minutes
Carnations	0.10	15 "
Grapes	0.09	over night
Cucumbers	0.15	over night
Coleus	0.10	20 minutes
Violets (Double English)	0.15	20 "
" (Single "	0.10	20 "
Chrysanthemums "	0.05	25 "
Tomatoes	0.03	over night

gram formula for from 30 minutes to 1 hour. For buds, grafts, scions and peach trees under 3 feet, use 0.16 gram per cubic foot. Do not fumigate nursery stock after the buds have started in the spring or before they have become dormant in the fall. Cyanide fumigation is useful only for insect pests, since it has little or no effect on fungous spores.

(d) **For orchards.** Cyanide fumigations have been extensively used for the treatment of citrus trees infested with scale insects, and to a lesser degree for other tree fruits. The gas is generated in an earthenware jar or in special fumigating machines, and confined by some form of canvas tent. In the eastern United States the 0.20-gram formula per cubic foot of enclosed space has given satisfactory results for deciduous trees, while about half that amount has been used for citrus trees in California. Bulletins published by the University of California Experiment Station contain detailed directions concerning styles and handling of tents, dosage tables for orchard work, etc.

Bulletin 79 of the Bureau of Entomology obtainable from the Department of Agriculture, Washington, D. C., from which Figs. 572 and 573 are taken also covers this subject completely and in full detail.

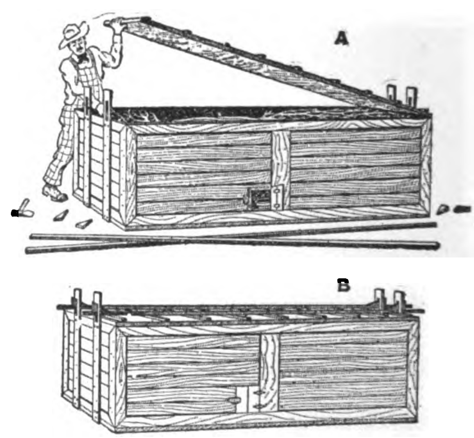


FIG. 571. Fumigating box for nursery stock. The top is held down by cross bars and wedges; the chemicals are inserted through the little door. (Ky. Bulletin 172).

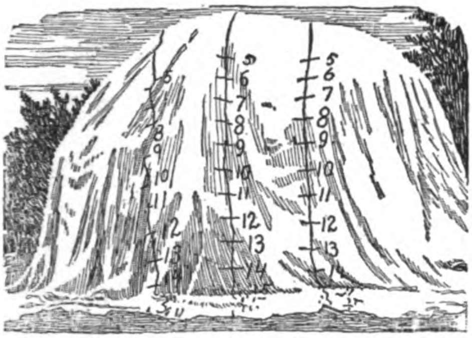


FIG. 572. Tent for fumigating oranges. There are corresponding figures on the other side. The sum of the figures nearest the ground in the centre row gives the distance over the tree, which is used in computing the dose needed.

FIG. 573. Row of orange trees tented and ready for hydrocyanic acid gas fumigation by means of materials carried on the truck. (This and Fig. 572 from Bulletin 79, U. S. Bureau of Entomology.)

V. Sanitary Measures

These are mainly in the nature of preventive steps, but oftentimes they deal with material already diseased or so weakened that it is easily subject to infection or injury. They are especially important in the control of diseases caused by organisms too small to be easily seen, and which the farmer is likely to overlook as important causes of trouble.

The following sanitary measures will be outlined briefly:

A. Removal and destruction of mummies or rotted fruits in which the fungus overwinters or the insect pest hibernates.

B. Removal and destruction of intermediate hosts; for example, the barberry in the control of stem rust of wheat, and the red cedar in the control of apple rust.

C. Destruction of other hosts. Fungi may spread from wild hosts to the cultivated crop and many insect pests have weeds as their original food plants.

D. Avoidance of proximity to other or intermediate hosts. (See B above).

E. Removal and destruction of the fruits of higher fungi, such as toadstool forms or bracket fruits. This should be done before they reach maturity so as to prevent the spread of spores to other hosts; it is to be practised in the case of wound fungi in orchards, or definite disease-producing forms like the fungus of mushroom root rot.

F. Destruction of dead leaves in which the organism winters over. Such measures are never perfectly effective alone but are valuable in supplementing other methods of control, especially in many leaf-spot diseases and in other troubles infesting the foliage of fruit trees or plants.

G. Destruction of dead debris in general —dead stems, leaves or fruits. In such troubles as white rust of oyster plant or downy mildew of the onion, the over-wintering spores are set free by the breaking down of plant parts remaining on or in the ground. In the potato, the stalk-borer winters over in the old, dead stems. Especially in truck gardens the general practice of cleaning up and burning all plant debris is a good one, and will lessen the damage from insect pests, or fungous diseases.

H. Removal and destruction of whole plants. In some cases, especially of perennial crops, this is the only thing to do. The tree or plant may be hopelessly infested with an insect pest, or the fungous parasite may be both internal and perennial. This is illustrated in trees badly infested with shot-hole borer or by blackberries or raspberries affected with orange rust; the fire-blight, a bacterial trouble, may be so severe as to call for equally drastic measures.

I. The removal and destruction of diseased (localized) parts. This should be done when the trouble is localized. Less severe types of fire blight infesting the twigs only may be treated in this manner, or the infested canes of small fruits like blackberry or raspberry, or the small branches of trees harboring borers or insect eggs, may be pruned out and destroyed.

J. Prevention and protection of wounds, which offer easy avenues of entrance for many parasites. In pruning operations, it is desirable that cut surfaces of the larger branches should be protected by a coating which will prevent evaporation and checking and exclude wood-destroying fungi or other more serious forms. The following materials have been used and are placed in the order of preference:

(1.) **Coal tar**, the product derived from the

FIG. 574. **Remove and burn all brush, especially diseased branches, immediately after pruning the orchard**

manufacture of artificial gas from coal.

(2.) **Asphaltum** which must be applied hot. It can be made easier to handle by dissolving it in gasoline.

(3.) **Paint** which is rather inefficient.

If parts attacked by infectious diseases such as fire blight, crown-gall, etc., are being removed, there is danger of spreading the infection by the pruning tools. These may be disinfected by the use of corrosive sublimate, 1 part to 1,000 parts of water.

K. Cutting out of cankers. In definite cankers on the trunk or larger limbs, the diseased parts, bark or wood, may be removed, the cut surfaces being then sterilized and waterproofed. On fruit trees, they may be painted with a strong solution of bluestone or corrosive sublimate 1-1,000, and then waterproofed. (See J). To hasten their healing, the cuts should be made pointed both above and below, rather than square or oblong.

L. Filling of cavities may be necessary in large orchard trees or shade trees. The operations consist of the following steps:

(1) Removal of *all* decayed wood. (2) Sterilization of the cut surface. (3) Waterproofing of the cavities. (4) Filling of the cavities.

If any decayed wood is left, the fungus causing the rot will continue to develop, and only temporary relief will be given. In treating the cut surfaces, it is of advantage to apply a coating of shellac over the bark and cambium (inner bark) to prevent injury from the poisonous antiseptic. As soon as this coating has dried, the entire cut surface may be sterilized with strong bluestone or corrosive sublimate (1-1,000) for orchard trees, and creosote for shade trees, this to be followed with a coating of coal tar. (See J.) The most satisfactory filling for tree cavities is concrete or cement. Important points to observe are: (1) Make a pointed or diamond-shaped cut, lengthwise of branch or trunk. (2) Provide for drainage of the cavity. Leave no blind pockets in which water may accumulate. (3) Use cross bolts for braces and other reinforcing when size of cavity makes this necessary. (4) Use cement in sections (12-18 inches), separated by layers of building paper, in all long cavities.

M. Burning of grass or stubble, is not an agricultural practice to be generally recommended, but it may be employed in special cases. Ergot-infested meadows may be so treated, while the depredations of the chinch bugs, army worms, locusts, and wheat jointworms may be lessened in a similar manner.

N. Avoidance of infected soil. Fields or gardens may become infected with soil fungi or insect pests that spend a part of their life buried in the ground or beneath soil debris. A number of the important troubles which may originate from infected soils are the Rhizoctonia disease of potatoes and other crops; the wilt diseases of cotton, potato, etc.; wire worms, root maggots, etc.

O. Avoidance of infected fertilizer. Barnyard manure may become infected and then carry the disease-producing organism to clean fields. The spores of corn smut find in the compost heap ideal conditions for their development, and not only remain alive but actually increase by the production of new spores of a different form. The bacteria of common potato scab are capable of passing through the digestive tract of animals without losing their infective power. Thus where scabby potatoes are fed to live stock, there is danger of returning the disease organisms to the field. These are but two common examples.

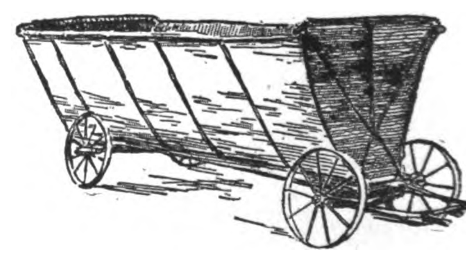


FIG. 575. **A metal-lined wagon may be used to burn small prunings as fast as collected**

VI. Planting and Cultural Practices

These intimately relate to the development and spread of many insect pests and fungous diseases. This means that in many cases the mower, rake, plow, harrow or weeder used in the proper way are as effectual as insecticides and fungicides and the spray pump.

A. FALL PLOWING

(a) Deep plowing may be used to good advantage against some of the common, injurious insects which spend the winter on or in the soil or surface plant debris in either the egg, larva, pupa or adult

stage. The life history of the pest must be understood in order to take proper advantage of this method. Grasshoppers' eggs which are laid on grass and stubble, if turned under to a depth of 5 or 6 inches, may hatch, but the young will be smothered without ever reaching the surface. Even adult insects may be buried and smothered, as results in fall plowing land infested with the cotton boll-weevil.

Insects which normally hibernate (spend the winter) below the surface may be exposed and devoured by birds or succumb to unfavorable weather conditions before establishing themselves in new winter quarters. This is why fall plowing is of value in the control of corn-stalk borer, wire worms, sugar-cane borer, corn-ear worm, cut worms, root maggots, etc.

(b) Early fall plowing with cultivation has been the most effective means of controlling the Texas root-rot of cotton. Frequent cultivation aërates the soil and kills the soil-dwelling, disease-causing fungus. Similar practice should be tried for soils infested with the sterile fungus, Rhizoctonia.

(c) Replowing of summer fallow just previous to seeding. In the Pacific Northwest, summer-fallow fields are covered with wind-blown spores of bunt or stinking smut. Replowing buries many of these spores below seeding depth where they cannot reach the young, developing seedlings, and so very materially lessens the per cent of infection.

B. CULTIVATION is of more or less value in reducing losses especially in the following connections:

(a) Late fall or winter cultivation in crops other than field crops in which the ground is not generally plowed, serves the same purpose as plowing. For example, the hibernating puparia of the gooseberry or currant fruit flies may be brought to the surface and in this way destroyed.

(b) Thorough disking in the spring is of value in controlling the garden webworm in alfalfa.

(c) The use of a spike-tooth harrow or disc after the crop has been cut, to be followed by a brush drag reduces injury to alfalfa from such pests as the leaf weevil and the clover-root curculio.

(d) Spring cultivation may be necessary to destroy insects before they transform into the adults. It must be timed to life history of the insect.

C. CLEAN CULTURE. The practice of clean culture popular in certain orchard sections for the conservation of soil moisture, has an important bearing on certain plant diseases. In apple scab, for example, the fungus lives over winter on fallen leaves, and where clean culture is practised, they may be buried and so eliminate an important source of infection.

FIG. 576. Corn plant badly infested with chinch bugs. (Farmers' Bulletin 657)

In many cases a cover crop offers a refuge for insect pests, and makes impossible the destruction of the wintering stage of fungous diseases. Clean culture is a recommended practice in the control of Buffalo tree-hopper and grape-leaf hopper.

D. USE OF A COVER CROP. The apple rosette of the Pacific Northwest can be very largely controlled by the use of alfalfa as a cover crop. Cover crops have a marked effect in reducing certain types of winter injury, probably as a result of producing a maturing of the wood and making the young twigs less succulent. For this reason they may even lessen the ravages of fire blight, and cases have been observed where even a weed cover proved of value in checking this disease or at least in reducing its severity.

E. THE CONTROL OF WEED PESTS. From the standpoint of diseases or pests, weeds are generally harmful (see exception under D) in that they serve as food or breeding places for many of our crop insects, or harbor fungi which may spread to cultivated hosts. In general practice, the weedy farm will show more insect pests than the well-kept farm. Even fungous diseases like our cereal rusts are increased in severity by an abundant undergrowth of weeds, which prevent penetration of sunlight, and check evaporation, thus offering more favorable conditions for spore germination and infection. "Volunteer" plants of the variety being grown are in reality weeds. They are generally out of season and so offer food for insect pests after or before the main crop is ready. Volunteer cotton in the spring affords feed for the boll-weevil and volunteer wheat during late summer and fall is available for the Hessian fly. In general, volunteer plants of our cereals are frequently attacked by rusts which later may spread to the main crops. (See also V, C, p. 513).

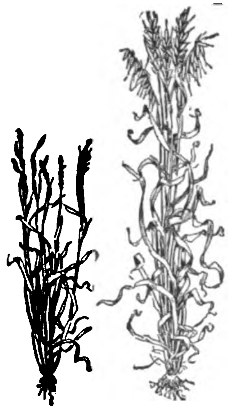


FIG. 577. Smutted (*left*) and healthy (*right*) oat plants showing the effect of disease on growth.

F. CROP ROTATION (p. 437). Single cropping is almost certain to lead to disease or to the increase of insect pests. One of the principal reasons is the existence of many fungi or insects in the soil, which increase in numbers or amount with the continuous growth of the same crop. Single cropping may thus increase the severity of a soil infection until the production of a paying crop is absolutely impossible. (See V, N, p. 514). This is true in the case of wilt diseases, potato scab, the Rhizoctonia diseases, weevils of peas and beans, craneflies in alfalfa and clover, etc. In other cases where soil infection does not increase in severity from year to year, but is annual, rotation will do much to lessen the trouble, notably in the case of bunt or stinking smut of wheat in the Pacific Northwest.

G. AVOIDANCE OF CERTAIN FERTILIZERS which promote the severity of fungous or bacterial troubles.

(a) **Lime.** The addition of lime to the soil increases the severity of potato scab.

(b) **Barnyard manure.** This also increases the severity of potato scab.

(c) **Nitrogen.** Nitrogenous fertilizers promote a vigorous growth of succulent tissue and so increase the danger of fire blight in pears, apples, etc. The powdery mildew of wheat shows a similar relation, and the tendency of cereals to lodge is promoted by heavy nitrogenous fertilizers.

H. THE USE OF CERTAIN FERTILIZERS.

(a) **Lime.** The application of lime to a Rhizoctonia-infected soil is of value since it produces an alkaline condition unfavorable to the fungus. Alfalfa failures may be due to acid soils which may be corrected by liming.

(b) **Barnyard manure** is of special value in lessening the severity of the Rhizoctonia disease on various hosts. Since the disease is one in which the roots are destroyed, the plants need stimulation to make the new growth keep up with the destruction that is going on. Fertilizers may have a similar effect in preventing loss from root-feeding insects.

I. TIME OF SEEDING.

(a) **Early seeding.** Early seeding, to give the plants a good start before wire worms begin extensive feeding, is a valuable practice in the control of this pest on sugar beets. Seeding of wheat in August in the Pacific Northwest before the smut shower, gives a smut-free crop or only a slight infection. Early seeding in the spring is preferable for oats in regions where rust is severe, since late plantings are subjected to secondary infection from earlier fields in the vicinity.

(b) **Late seeding.** Late fall seeding as opposed to mid-season seeding is recommended as one of the measures in the control of Hessian fly, and is also one of the means of lessening the per cent of bunt or stinking smut in wheat.

(c) **Spring seeding.** With properly-treated seed, spring planting of wheat gives a smut-free crop, while in regions where summer fallow is practised, the most carefully treated fall-planted seed may produce a smutty crop.

(d) **Fall seeding.** Fall seeding as opposed to spring seeding of wheat lessens the severity of rust, not because the winter wheats are more resistant, but because the crop ripens before the rust has had time to make its maximum development.

J. DEPTH OF SEEDING OR SETTING must be suited to the crop and is to some extent proportional to the size of the seed.

(a) **Avoid deep seeding or setting.** In general deep seeding increases the per cent of infection from bunt or stinking smut in wheat; while deep setting is one of the causes of physiological gummosis in stone fruits.

(b) **Practise deep seeding or setting.** Tomatoes that are liable to attack from Rhizoctonia may keep ahead of the disease by the production of new roots, if set nearly to the first leaves or cotyledons.

K. RATE OF SEEDING. Troubles may call for either (a) an increase or (b) decrease in the normal rate of seeding.

FIG. 578. Club root of cabbage is caused by a microscopic organism that is destroyed by lime.

VII. The Control of the Water Supply

The water relation of our crop plants is so important in its effects upon plant troubles that it will be considered independent of other cultural practices. Ex-

cept under the ideal condition of a well-planned and effective irrigation system, the regulation of the moisture supply may be somewhat difficult. For the plant or crop, there is an optimum (best) water content of the soil, but just this desirable condition may promote disease. We are concerned with reducing or increasing the amount of water available or with different methods of application.

A. REDUCE THE WATER USED IN IRRIGATION either by less frequent irrigations or by watering for shorter periods. Like the use of strong drink, the use of irrigation water is intoxicating, for the grower is stimulated by the response which plants make to plenty of water, to use a little more. The result is that over-irrigation and over-growth are not uncommon. This is just the condition which favors a bacterial disease like fire-blight of apple and pear, increases the severity of powdery mildew of apple or wheat, and aggravates such non-parasitic troubles as bitter rot of apple and winter injury of fruit trees in its various forms. An excess of moisture seems to be favorable for the increase of soil-infesting nematodes, and greenhouses that are kept especially damp are frequently overrun with sow bugs.

B. INCREASE THE WATER. Under-irrigation may be the direct cause of troubles, due in perhaps the majority of cases, to insufficient supply. In others, the grower does not understand his crop requirements, or misjudges the water-holding capacity of a soil. Alkali injury may be lessened by copious winter or late fall irrigation, and in general saline (salty) waters should be used more abundantly than purer ones. Spot necrosis of the apple is a drought spot, due to an insufficient and intermittent supply of water. Winter injury, which is promoted by over-irrigation, may also be aggravated by water shortage. Fruit trees or small fruits that go into the winter without sufficient water may suffer a fatal winter drying. Even insect pests may be partially or completely controlled by flooding the infested fields. Submersion for 4 or 5 days after the crop is harvested is a quick and thorough means of exterminating the strawberry-crown moth.

FIG. 579. Diseases are often spread by insects. This half of a seedbed was left unscreened (see Fig. 580)

FIG. 580. This half of the seedbed (see Fig. 579) was screened. (Both from N. Y. Bulletin 334)

C. WATER THE SOIL, NOT THE PLANTS. In greenhouse crops, spraying with a garden hose is a means of spreading certain fungous diseases. If rust appears in carnation beds, the successful grower keeps it in check by watering with an open hose between rows. A disease like the late blight of celery may be spread and increased in severity by running the irrigation water down the rows, rather than between them.

D. DISCARD THE OVERHEAD SPRINKLING SYSTEM. In some flower or truck gardens, the use of the overhead sprinkling system for irrigation has worked disastrous results. Certain foliage diseases are favored by these artificial rains; the anthracnose of lettuce may cause the complete loss of a crop under such conditions.

E. USE SUBIRRIGATION. In a few field irrigation projects, this method is practised, but it is of greatest value in raising certain greenhouse crops, the permanent piping for soil sterilization II, B (p. 505) being used. Lettuce drop, a disease which nearly put the growers of greenhouse lettuce out of business in some eastern sections, is easily controlled by soil sterilization and subirrigation.

F. AVOID WET SOILS. Certain soils predispose to disease even though they are not infected with a disease-producing organism, especially those that are naturally overwet. The powdery scab of potatoes is serious only in wet, heavy soil where the temperature factor is favorable.

G. RESORT TO DRAINAGE which is but a means of avoiding wet soils without a change of site. It has an effect upon the natural weed pests and upon the severity of insect enemies of certain crops, as well as upon non-parasitic diseases. Proper drainage is of value in the control of the rice weevil, and corn bill-bugs soon disappear from well-drained land.

VIII. Selection of Site

Soil characters and topography are factors which not only have direct influence on crop production, but also show a pronounced effect on many plant troubles. Climatic conditions may predispose to certain diseases or limit their spread. The avoidance of infected soils has been noted under V, N, and the avoidance of wet soils is considered under VII, F.

A. AVOID SOIL WITH UNDERLYING HARDPAN OR ROCK particularly in the case of crops which have a deep root system. Alfalfa and tree fruits are sometimes a failure on account of underlying hardpan, or similar faulty physical conditions. Such soils may give an over-saturation of water during the rainy season, a shortage during the dry season, and may limit root penetration, thus causing die-back and other non-parasitic conditions.

FIG. 581. Root galls resulting from injury by nematodes or eel worms.

B. AVOID SITES WITH HIGH WATER TABLE. In some regions the natural water level is near the surface for all or part of the season, which feature should be kept in mind, as it may prove as serious to plants with deep root systems as hardpan or underlying rock. Fruit trees, for example, can not stand "wet feet," the roots being injured and often killed, so that the top may be indirectly affected; yellowing and dropping of foliage, and die-back may result. After plantings have been made, there may be changes of water table which will prove disastrous. Sites adjacent to large irrigation canals may have a high water-level, especially if the soil is sandy or gravelly, and the canals are uncemented. If such places have already been utilized for orchard plantings, the obvious remedy is drainage or the cementing of the bottoms and sides of the main ditches.

C. AVOID POOR OR LIGHT SOILS which, especially in the case of orchards or vineyards, frequently cause failure on account of objectionable physical properties or deficiencies in essential nutrients. The use of these poor or light soils for extensive plantings has been of frequent occurrence in both apple and citrus fruit sections, as a result of the activities of large orchard promotion companies. The following conditions are to be avoided with specific crops:

(a) Light sandy soils with poor water-holding capacity, which are a common cause of winter injury.

(b) **Soils short in potash.** Shortage of potash is an important factor in internal brown spot of the potato, and potash hunger has been noted as a pronounced disease of tomatoes. The use of a potash fertilizer can be resorted to if the poor soil cannot be avoided.

(c) **Soils short in phosphorus.** The brown-bark disease of apples is intimately related to shortage of phosphorus. Avoidance is preferred to correction.

(d) **Soils short in nitrogen.** If this deficiency can not be avoided, it is easily corrected by adding barnyard manure, artificial fertilizers, or growing leguminous crops.

D. AVOID HEAVY, POORLY AËRATED SOILS which are especially favorable to certain bacterial diseases like black rot of cabbage and black-leg of potato, and which predispose stone fruits to physiological gummosis.

E. AVOID OR CORRECT ACID SOILS which, while they do not cause specfiic diseases of our crop plants, do offer conditions most favorable for the development of certain parasites. Root-infesting nematodes multiply more rapidly in acid soils and Rhizoctonia diseases are increased in severity.

F. AVOID OR CORRECT ALKALI SOILS. Some species of plants prefer alkali soil, but the majority of our crop plants suffer if forced to grow in soils with a pronounced alkali content. Flooding and drainage are the most

FIG. 582. Root gall on apple caused by the wooly aphis

important practices for reclaiming alkali lands. Alkali soils may cause death of seedlings in a manner not unlike "damping off," or the plant may survive but be dwarfed and fail to develop fruit. In the case of established plants, there may be yellowing of foliage, poor leaf development, crown injury, etc.

G. AVOID REGIONS OF LATE SPRING OR EARLY FALL FROSTS. Elevation or topography frequently render certain localities annually subject to late spring frosts. The establishment of extensive plantings of frost-sensitive crops in such localities should be discouraged.

IX. Harvesting and Storage Practices

There are some troubles which can be controlled, in part at least, by special practices or precautions observed in harvesting or storing crops.

A. EARLY CUTTING is designed to interrupt the completion of the life cycle or, wherever possible, to prevent development of the over-wintering stage of the parasite. Two notable illustrations among fungous diseases are leaf spot and downy mildew of alfalfa; the clover-seed midge may be partially controlled in a similar manner.

B. AVOID BRUISING OR CUTTING. This is in reality a sanitary measure (V, J, p. 513) which prevents infection or renders it less likely. Root crops of various kinds are invaded by rot-producing bacteria or fungi, but many of these cannot penetrate an unbroken skin; wounds of any kind offer easy avenues of entrance. The importance of care in handling is to be emphasized especially in the case of potatoes. Care in picking fruits like apples, pears, and peaches, is even more important.

C. AVOID VINES WHEN WET WITH DEW OR RAIN. Agitation of plants at such times is an effective means of spreading spores. The spread of bean anthracnose by picking the pods when the vines are moisture-laden is typical.

D. USE LOW TEMPERATURES FOR STORAGE. If root crops or fruits are to be held for any length of time, they must be subjected to low temperatures to prevent loss from rotting. Refrigeration or low temperatures retard the growth of fungi already started, and lessen the number of new infections. *Dry air and good ventilation* are valuable adjuncts. In general, a temperature below 45 degrees F. but above freezing should be maintained. It is important that perishable crops should go into cold storage as soon as possible after harvesting, since delayed storage gives an opportunity for infections to start.

E. AVOID HEATING OR OVERHEATING. Sweating or heating of root crops favors infection with rot-producing fungi. In the case of leak or melters of potatoes, pains should be taken to avoid piling the newly harvested tubers so they will sweat. Overheating of potatoes in transit or in storage is the cause of the non-parasitic disease known as black heart. Under storage conditions, a temperature of 99 to 104 degrees F. for a day or more is sufficient to cause the trouble.

FIG. 583. Peach yellows is a mysterious disease that dwarfs the fruit, kills the branches and causes the development of bunches of shortlived, tender growth.

F. WRAPPING, aside from retarding water loss from fruits, is a valuable adjunct in preventing infection with rot-producing fungi.

G. DISINFECTION OF WASH WATER. If fruits are washed in preparation for market, there is a chance that the wash water may become infected and cause trouble. A striking illustration is the infection of lemons with brown rot in the wash water of the scouring machine. Potassium permanganate in the water at the rate of 1 pound to 625 gallons, is an effective control.

H. REDUCE THE PERIOD OF STORAGE. Using clover during the first year of storage will prevent loss from the clover-hay worm. In case of apples subject to bitter pit which increases during the storage period, early marketing will reduce the loss.

X. Special Devices

A. USE OF POISONED BAIT.

(a) Poisoned bran. Wet 40 pounds of bran until the water can be squeezed out in the hand, then stir in 2 gallons of molasses and 5 pounds of white arsenic. Scatter in small piles in the pathway of the pests.

(b) Citric bran mash.

(1) Mix dry 50 lbs. . wheat bran
2½ lbs. . white arsenic or Paris green

(2) Mix thoroughly ½ doz. lemons, including rind, chopped fine.

4 quarts. . . . Sirup or molasses
5 gallons . . . Water

For use, mix 1 and 2 just before using and add sufficient water to make a wet mash.

(c) Criddle mixture. Mix 1 pound of Paris green with water and stir it into a mixture of 60 pounds of horse dung and 2 pounds of salt.

(d) Slices of carrot, raw potatoes or other vegetables may be rolled in Paris green and placed in the haunts of the pest.

B. DEVICES FOR CAPTURING AND KILLING INSECTS.

(a) The hopperdozer or hopper-cage. The first is a horse-drawn apparatus consisting of a back and sides of sheet iron or canvas and a pan containing water and kerosene or crude oil into which the insects fall. A different type without an oil-pan may be used in very hilly districts. The hopper-cage, for the capture of the vine leaf-hopper, consists of a framework of laths which is covered with a double layer of wire window screen or a single screen of 20 meshes to the inch. The bottom consists of a shallow pan of galvanized iron provided with a V-shaped opening, thus permitting the cage to be pushed over the vines. The sides of the cage and the tray or pan are smeared with crude oil, in which the hoppers are caught when jarred from the vine. A curtain on the open side of the cage may be used in calm days, but when there is a breeze, the cage may be effectively operated with the open side facing the wind.

FIG. 584. The cabbages in the left half of this field were protected by discs; those on the right were not. The same number of plants were set out to begin with.

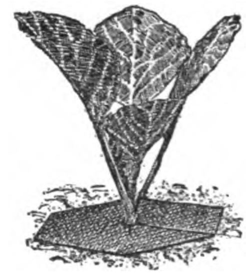


FIG. 585. Cabbage plant protected from root maggots by a tar paper disc.

(b) Light traps. These depend upon the attraction of insects to a light during their nightly flights. Various types are available in all of which the essential features are a light in the centre of an oil pan or basin into which the light-intoxicated insects fall. In some forms, deflectors are introduced to interrupt the circular flight of the insects and throw them down into the pan. Light traps may be used for capturing any night-flying insects, but they have been installed especially for catching the adults (moths) of cut worms and army worms. This method is only partially effective since many of the adults will already have laid eggs before being captured.

(c) Board traps. Pieces of boards placed on the ground near the host plants may be used as a refuge by certain insects. If they are lifted early in the morning the pests may be collected and destroyed. Squash bugs are easily captured in this way.

(d) Poultry. With a little careful planning the farm flock of chickens may be given the run of the orchard and materially assist in keeping insect pests in check. The appetite of ducks for potato bugs has frequently been noticed, and in some localities, flocks of turkeys are used for the destruction of the tobacco horn worm.

(e) Use of trap or catch crops. Another host plant, frequently one preferred by the pest, planted earlier or along with the crop or, some of the crop itself, may be utilized. The selection of the trap crop and its successful use requires more or less knowledge of the life history and habits of the pest to be captured. The use of a trap crop for eel-worms or nematodes has long been recommended, the catch crop being collected and the eel-worms destroyed. The use of early-seeded wheat to be plowed up after the eggs have been laid is a control method for Hessian fly. Asparagus beetles lay their eggs on seedlings, or other shoots which, if left during the first part of the cutting season, may be destroyed together with the eggs, a little later. A crop of early kale may be used to attract the Harlequin cabbage bug which may be killed by spraying and so prevent damage to the later cabbage crop. The

corn ear-worm may be kept from its other, less-preferred hosts like tomato, tobacco and cotton, by a catch crop of corn.

(f) **Jarring into traps.** This method may be followed whenever the insect pest will loosen its hold and fall if the host plant is suddenly jarred. It finds its practical application in the control of certain beetles, which generally feign death for some time after they fall. In the simplest method, large sheets are spread beneath the trees and the branches jarred by striking them with a padded mallet. For curculio of plum, peach, etc., 2 light frames, 12 x 6 feet on which sheets are stretched may be held under the trees by 4 persons, while another jars the tree. Where orchard conditions permit, the wheeled curculio catcher (Fig. 589) may be employed. This is a large, funnel-shaped frame covered with canvas and mounted on a two-wheeled wheelbarrow.

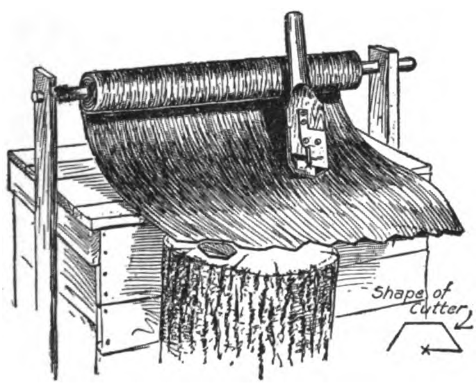


FIG. 586. Device that any farmer can make for cutting discs from roofing paper. A blacksmith can make the cutting blade. (O. Bulletin 190.)

A narrow opening reaching the centre, admits the trunk of the tree so that the catcher can be placed directly beneath the branches. The beetles fall on the canvas and roll down into a collecting receptacle placed under the centre of the funnel. In any method, the beetles must be collected from time to time and killed.

C. **THE USE OF BARRIERS** of some sort to prevent the advance or migration of insects, or occasionally of fungi is often effective.

(a) **Banding.** Band barriers or cone protectors are placed around the trunks of trees to prevent crawling insects from ascending. Sticky materials are frequently used, while ropes saturated with a mixture of crude oil and asphaltum or of pine tar and molasses have been effective. If trees attacked by tussock moths or canker worms

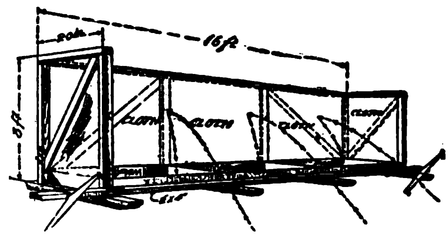


FIG. 587. Construction and dimensions of one form of hopperdozer. (Farmers' Bulletin 747)

are jarred, many of the caterpillars will be shaken to the ground, and proper bands of the above materials or of burlap will prevent them from again ascending. Burlap bands are used to a considerable extent in New England in fighting the gypsy and brown-tail moths. Cone protectors have been used on small orchard trees to exclude bud weevils and climbing cut worms.

(b) **Fences and similar barriers** are limited to checking the migration of insects which move in large numbers. In checking the migration of the Coulee cricket in the state of Washington, 15 miles of fence was constructed in a single locality. Eight-inch boards capped with a projecting strip of galvanized iron were placed on edge end to end and held in position by small stakes.

(c) **Furrows or trenches.** A furrow made with an ordinary plow may suffice in certain cases, while in others deeper trenches must be dug. Plowed furrows may be used to check the march of army worms, the retarded army being killed by spraying with a strong contact insecticide. Deep trenches with still deeper pitfalls have been used against crickets. In a few cases trenching may serve to check the advance of fungi through the soil. It has been tried with some success against the violet Rhizoctonia of alfalfa and clover, and the mushroom root-rot of trees.

D. **THE USE OF REPELLANTS.** Chemical compounds may be applied to crops by spraying, painted on tree trunks, used as steep for seed, or added to the soil. (See also III, p. 506).

(a) **Whitewash.** For *ordinary whitewash*, slake 10 pounds quicklime and add water

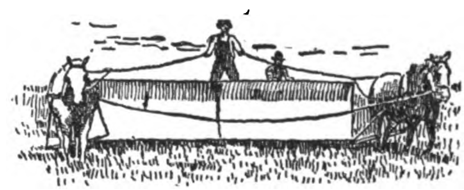


FIG. 588. A hopperdozer in use

Fig. 589. A curculio catcher in use

to bring to the right consistency (about 2 gallons). For *carbolated whitewash*, add 1 pint crude carbolic acid (25 per cent) to 10 gallons of ordinary whitewash. Whitewash is used on the trunks of trees to lessen the danger from sunscald, and ward off attacks of borers.

(b) **Kerosene and sand** mixed may be put around the stems of plants susceptible to injury by root maggots.

(c) **Repellants for use on seed.** Various substances have been used as repellants on seed previous to planting, with more or less success. Among these may be mentioned: oil of lemon, carbolic acid, formalin, kerosene, chloride of lime, and flowers of sulphur. Care must be taken to use a strength which will not materially reduce the germinating power of the seed.

(d) **Lime and crude-oil mixture.** Slake 50 pounds rock lime in 10-15 gallons of water; while still boiling add 6 to 8 gallons heavy crude oil, and stir thoroughly. Dilute with water to make a heavy paste and apply with a brush.

(e) **Lime-sulphur-salt.** Slake 25 pounds rock lime with warm water, add 2 quarts sulphur and 1 pint salt while boiling, and stir thoroughly. Use water to make heavy paste and apply with a brush.

(f) **Lime, coal-tar and whale-oil soap.** Slake 50 pounds rock lime in warm water, and add 1½ gallons coal tar while the mixture is boiling. Dissolve 12 pounds whale oil soap in hot water and add with sufficient water to make a heavy paste.

(g) **Tobacco dust.** This should be fresh to be effective. It may be dusted directly on the insects or scattered where it will repel egg-laying adults. To repel root maggots heap it up around the stem of each plant.

E. BURNING WITH A TORCH is very largely limited to the destruction of colonies of tent caterpillars; special pains should be taken to keep from burning the bark of nearby branches.

F. MECHANICAL DESTRUCTION OF PARASITES.

(a) **Hand picking.** Because of their large size and characteristic work, the larvae of the sphinx or hawk moths may be easily located, and gathered and destroyed or cut in two with a pair of scissors wherever found. The egg masses of tussock moths, potato beetles, brown tail moths and others which are generally conspicuous, may also be located and destroyed. Brown tail and gypsy moth egg masses are effectually destroyed if painted with creosote.

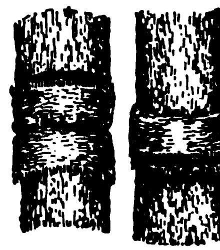


Fig. 590. Burlap bands to trap caterpillars. Examine every day or two and kill the insects found beneath.

(b) **Killing borers.** This may be done by digging them out or by inserting a flexible wire into their burrows.

(c) **Cutting or "breaking" out mistletoe** is done with a hook on the end of a long pole; it is only partially effective since the parasite sprouts again the next season. The work may be made more effective if, in addition, the bark is shaved off over the infected spots and coated with coal tar. Small branches with mistletoe should be pruned out and the breaking-out method employed only for the larger limbs.

G. PARASITE ENEMIES: THEIR INTRODUCTION, PROPAGATION AND PROTECTION. The natural enemies of insects here referred to are predaceous or parasitic forms of parasitic fungi. There is perhaps little that the grower can do in preserving the beneficial forms and helping along their work, but he should at least have an acquaintance with his assistants in plant production. He should recognize the lady-birds as his friends in the control of aphids, and the ichneumon flies as aids rather than pests. Such insect enemies serve as a natural check upon the injurious species, which, without such parasites, would probably be much more serious. The full use of insect parasites through their introduction

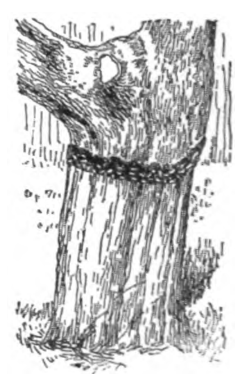


Fig. 591. A band of sticky material is a good caterpillar trap while it lasts.

from foreign countries and their distribution, is a work that can only be effective in the hands of experts. It has been undertaken by both state and federal departments of agriculture.

H. ORCHARD HEATING. Artificial heating of orchards is designed to raise the temperature to a point above danger of frost injury at the critical time when the normal temperatures would cause partial or entire loss of fruit or severe injury. Smudging may sometimes accomplish the same purpose and give protection by preventing the radiation of heat from the earth. For this purpose burn dampened straw or brush heaps over which coal tar has been poured.

Orchard heating is done by burning many small fires throughout the orchard, generally between the rows. Various types of orchard heaters adapted for either coal or oil are now available; from 50 to 80 per acre will be necessary.

Apples and peaches frequently need such protection from frost. The danger points for peaches are as follows:

Dormant buds	10° below 0
Appreciably swollen	0°
Showing pink	15° above
Almost open	26° above
Petals beginning to fall	28° above
Petals off	30° above
"Shucks" beginning to fall	32° above

Dormant apple buds will stand as low temperatures as the twigs, but there is always danger after the cluster buds have opened. When the petals show, the buds will generally stand 10-12 degrees of freezing, and when fully opened 4 degrees of freezing will cause heavy loss. After the flowers are fertilized 10 degrees of freezing is dangerous.

FIG. 592. Army worm invasions are checked by digging a trench along the threatened field, and dragging a log through it as it becomes filled with worms.

I. DIRECT TREATMENT with insecticides or fungicides is, in some cases, more effective than spraying.

(a) **Painting.** Aërial colonies of wooly aphis may be painted with pure kerosene, crude oil, or miscible oil (1-10 parts of water).

(b) **Dipping.** Seedlings that are to be transplanted, or nursery stock may be dipped in the fungicide or insecticide in the control of specific diseases or pests. This may be done in controlling aphids or young nursery trees, and is more effective than spraying after the leaves have been curled.

XI. Seed Selection and the Selection and Breeding of Disease-Resistant Varieties

A. THE USE OF DISEASE-FREE SEED OR STOCK. Certain of the seed-borne troubles can not be readily controlled by seed treatment; against these the selection of healthy seed or seed free from the germs of disease offers another avenue of escape. It is also equally important that all stock used for propagation such as cuttings, scions, bulbs, etc., be free from diseases or pests.

(a) **The seed-plot method** (for cereal smuts) can be applied particularly to the 2 smuts in which there is a blossom infection, namely, the loose smut of wheat and the naked smut of barley. For these troubles sufficient seed to plant one-fifth to one-twentieth of an acre is treated by the hot-water method (I. F. p. 505). As soon as the smutted plants appear—if any—they are rogued out, that is, they are removed before any smut spores are set free. The product from the first year is planted the second year in an increase plot which will, with proper care, furnish smut-free seed for the general crop for the third year.

(b) **Bin selection** (for potatoes) is the least desirable method but will help in disease control and the improvement of stock. Perfectly sound tubers free from any evidence of such troubles as wilt, Fusarium rots, blackleg, or late blight rot should be selected. Wilt-infected tubers can be detected only by cutting a slice from the stem end. Any tubers which show the characteristic bundle browning should preferably be discarded, but if necessary the bud end may be used, provided the stem end is cut away well below the discolored portion. If any considerable number of tubers show bundle browning, it would be advisable to use other stock for seed. In the interests of production, the seed tubers should be neither too large nor too small, those weighing 2 to 8 ounces being generally recommended.

(c) **Field selection** (for potatoes) at the time of digging is more satisfactory since there is a better opportunity for the choice of tubers as to size, uniformity, and

freedom from disease. If such diseases as blackleg, wilt, curly dwarf, leaf-roll or mosaic were known to be present in the field and the diseased plants were not removed, selection of seed from the field would be hazardous. Bruised or injured tubers should be discarded and the selected stock carefully handled and stored under favorable conditions. Field selection makes possible the use of seed from fields or portions of fields that show the greatest freedom from disease.

(d) **Regional selection or the use of certified seed (for potatoes).** In the first place the grower obtains seed from some other region, near or distant, with the purpose of improving production or eliminating disease. This practice requires a knowledge of the diseases that are prevalent in the section from which the seed stock is to be obtained.

For one who has not sufficient time for the production of his own seed stock, the use of certified seed offers an acceptable substitute. A number of states are already offering such seed, and the practice is one that is sure to be extended. "Certified seed" means that the seed stock so labeled has been produced under a careful system of inspection under state control, the rules and regulations varying in the different states. Such certified seed should show a freedom from the more serious tuber-borne troubles, and no more than a certain allowable minimum of the less troublesome diseases.

(e) **The tuber unit method.** (For potatoes). *First year.* (1) Select 100 tubers free from any signs of disease true to variety and perfect in form and ranging in weight from 5 to 8 ounces. Treat with corrosive sublimate using the standard formula (I, D, p. 504). (2) Quarter each tuber from stem to seed end and plant consecutively in tuber units of 4 hills, numbering and marking each unit. (3) Rogue during the growing season to eliminate weak or diseased plants. (4) At digging time, select 10 good tubers from each desirable unit, and store in separate, numbered bags.

Second year. Using the tuber units from the preceding year, plant each 10-tuber unit in units of 40 hills each. Rogue and select the best for the next season.

Third year. Using the best seed obtained from the previous year, plant a large seed plot, and at digging time select one or more of the most productive units for general field use. The productiveness, type and freedom from disease can then be maintained by careful selection of the seed each year, either from the general field or from a special plot.

(f) **The hill method.** (For potatoes). The tubers selected by this method represent the progeny of a single seed piece. Proceed as follows:

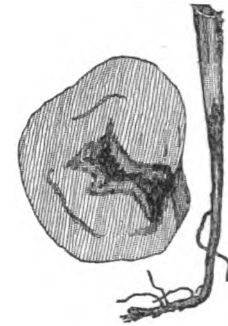


FIG. 593. Blackleg of potato showing rotted tuber and withered stem.

1. Inspect the field late in the growing season and mark hills which show freedom from disease and proper type of top. At harvest time, save those hills which show the best type and productiveness of the tubers. Discard hills for "off form" of tubers, lack of productiveness, or evidence of serious disease.
2. Preserve the progeny of each selected hill in a numbered bag.
3. Treat, cut and plant as in the tuber unit method (e above). If not possible to grow the selected tubers in hill units for further selection, the grower may put together the tubers from all of the selected hills; but the more careful selection will probably pay in the end.

(g) **The use of so-called resistant varieties.** Seed companies sometimes advertise resistant varieties which are in reality not resistant, but give a disease-free crop since the seed was produced in a region free from the trouble in question. A notable illustration is the "rust-resistant" varieties of string beans, which are so-called simply because free from seed infection with anthracnose.

B. THE SELECTION OF RESISTANT VARIETIES OR SPECIES

(a) **Apparent resistance.** In certain cases the crop escapes serious injury, not because of any specific resistance, but by maturing ahead of other varieties of the same crop. This is the explanation for the apparent rust resistance of hard winter wheats and 60-day oats.

(b) **Real resistance.** The experience of growers and the results of experimental tests show that it is frequently possible to list varieties into resistant, susceptible, and very susceptible groups, and such lists have been published by experiment stations in connection with many of our important crops. A few of many possible examples may be cited: Durum varieties of wheat and the Kanred show a marked resistance to stem rust; in general, the common or "*vulgare*" types of wheat are more resistant to bunt or stinking smut than the "*compactum*" or club types; Palmetto asparagus, a variety resistant to rust, has largely replaced

the susceptible Conover's Colossal; English varieties of gooseberry are much more susceptible to mildew than the American; the Chinese and Japanese chestnuts are much more resistant to the bark disease than the native American chestnut.

C. THE SELECTION OF RESISTANT STOCKS and their use for budding or grafting has afforded relief when none of the commercial varieties showed the desired resistance. It has been found, for example, that the California peach borer will not injure trees grafted on the Myrobalan plum. The Northern Spy apple is especially sought as a resistant rootstock for grafting, since it is nearly immune to wooly aphis. The use of resistant stocks has offered the most practicable method of avoiding the injury from grape phylloxera. Work now in progress gives promise that this method will be the ultimate solution of the fire blight problem of pears.

D. THE SELECTION OF RESISTANT INDIVIDUALS makes use of the recognized variation in susceptibility within the species or variety. Individuals that remain free from disease when exposed to infection, may, if selected and propagated, give rise to resistant strains. While this line of selection must

FIG. 594. How plant disease spreads. In 1908 (A) chestnut blight was severe in Connecticut over the blackened area and mild in the shaded section. By 1912 (B) it existed all over the state, the areas of severe and very severe attacks having increased as shown. (Conn. Bulletin 178.)

be carried out largely by experts, it should not be overlooked by commercial growers. Cotton and watermelons resistant to wilt, flax resistant to rust, cabbage resistant to yellows, and clover resistant to anthracnose, are some of the practical results of the work of investigators.

E. HYBRIDIZATION FOLLOWED BY SELECTION. The crossing of varieties in the hands of skilled scientific workers has already yielded results, and promises much more for their future efforts. The aim is to combine resistance with other desirable qualities.

FIG. 595. Whoever cares enough about a plant to grow it, should also care enough to protect it from its many enemies.

CHAPTER 35

Crop Protection Against Weeds

IF A man builds a factory to produce shoes, or stoves, or automobiles, the number and value (above their cost) of the articles produced are the things he is interested in. If a man operates a farm for the production of corn, or wheat, or hay, or vegetables—whether to be sold or turned into animal products—his first aim is to get as large yields as he can, economically. The weeds—that is, the useless crops—he raises are of no more benefit to him than the smoke that escapes from the factory owner's chimneys. Indeed they are, on the other hand, a direct source of loss, since they (1) compete for moisture and plant food with the crop plants; (2) lower the yields; (3) cheapen the seed, if to be harvested; (4) harbor insect pests and plant diseases; (5) injure or inconvenience pastured animals; (6) provide extra labor for the farmer and his men in killing them out; and (7) injure the good looks of the place, thus lowering its real estate value.

Against this list of absolute and serious disadvantages can be placed one benefit that some weeds sometimes effect. This is to occupy ground which, lying fallow, would be idle and might wash, leach or otherwise become injured. The decay of a weed plant adds some humus to the soil, it is true; and a growth of weeds will provide an orchard cover crop when a specially sown one is impracticable. But, why, when there are so many crops especially adapted to these purposes, crops that are nothing but beneficial, and that, if need be, can be harvested, pastured or used in sundry other ways—why accept second-rate goods for the sake of saving a little trouble, at the risk of considerable damage to the future welfare of the farm?—EDITOR.

The following paragraphs adapted from Farmers' Bulletin 660 of the United States Department of Agriculture, summarize the essential principles in weed control. Together with the table on pages 528, 529 and 530, they provide the farmer with information whereby he can recognize and proceed against the more serious of the weed pests that interfere with his work.

In fighting weeds, it is extremely important to know how long they naturally live, and their habits of reproduction. Weeds are divided into three classes according to their duration or length of life: (1) Annuals; (2) biennials; (3) perennials.

Annual weeds live only one year, maturing their seeds and then dying, like ragweed, smartweed, and crab-grass. Some annuals germinate in the fall, live through the winter, and mature their seeds in the spring. These are called winter annuals, and examples are shepherd's-purse, peppergrass, and fleabane.

Biennial weeds live 2 years. During the first year they grow rather slowly, producing usually a taproot and a rosette of leaves close to the ground; the second year they send up flower stems that produce seed, and then die. Examples are blueweed, bull thistle, and wild carrot.

Perennial weeds produce each year underground parts which live over the next year and produce top growth. These underground parts may consist of long, more or less horizontal roots, as in the case of the bull nettle, milkweed, and Canada thistle; or of rootstocks or underground stems, as in the case of quack-grass, Johnson grass, and perennial sow thistle; or of bulbs that split up, as in the case of wild onion; or they may be more or less in the form of a taproot, as in dandelion.

The Control of Weeds

Far more important than to kill weeds is to avoid having weeds to kill. In other words, the farmer should aim to prevent rather than cure the evil. A farm can be made almost free of weeds by strictly observing the following principles: (1) Prevent weeds from going to seed on the farm; (2) prevent weed seeds

being brought to the farm; and (3) in the case of perennial weeds, prevent them from making top growth and thus finally starve out the underground parts.

Annuals and biennial weeds propagate themselves by seeds alone. In dealing with them it is necessary to observe only the first two of the above principles. Most perennials propagate themselves by their underground parts as well as by their seeds; hence, even if prevented from going to seed, they still keep on growing. In dealing with them, therefore, it is necessary to observe all three of the above principles.

Preventing weeds from going to seed on the farm. The number of seeds produced by weeds varies with different species, most kinds producing from one hundred to several thousand seeds per plant. Some weeds, such as wild carrot, burdock, and sow thistle, are capable of producing 20,000 or more seeds to the plant. Moreover, many of these seeds do not germinate at once, but delay sprouting for a period, some of them for several years. This is the basis of the old saying, "One year's seeding makes seven years' weeding."

If it is not practicable for the farmer to dispose of his weeds when they are small, he should make every effort to prevent them from going to seed. If weeds are attacked when the most advanced have just reached the full-blossom stage, they can be prevented from seeding. At this stage, too, the roots are at their weakest, especially those of the annuals and biennials, which are largely exhausted. No time should be lost, however, in disposing of weeds when the full-blossoming stage has been reached, as seeds will shortly be formed. Some weeds, such as pigweed, produce blossoms that are small and easily overlooked, so that unless closely watched, they will go to seed before one is aware of it.

Tillage to control weeds. While tillage in its relation to weeds usually is practised for the benefit of the immediate crop, it also may serve the purpose of preventing hosts of weeds from maturing seeds. Thorough tillage serves the additional purpose of encouraging the rapid germination of weed seeds in the soil while killing the weed seedlings when young. In no way is the old adage "A stitch in time saves nine" better illustrated than in killing weeds by tillage soon after they have germinated rather than delaying the work until they have attained some size.

Mowing to prevent seeding. Mowing is another way of preventing weeds from going to seed. As a rule, it is best to mow when weeds have reached the full-bloom stage. Many farmers mow their pastures once or twice each year and as a result gradually drive out the weeds and thicken the grass stand. When there are patches in grain fields thick with weeds, it will pay to cut them, grain and all, before the weeds start to go to seed. Most careful farmers mow or cut their fence-row and roadside weeds once or twice a year to prevent their seeding.

Hand work to prevent seeding. Quite often a few scattered weeds will occur in a field. These can be pulled out or dug out with a spud or mattock with little work, whereas if allowed to mature, they would thoroughly seed the land and make trouble for the future. Annual and biennial weeds will make no further appearance if pulled or cut off when they are in full blossom. The spud is a tool with a long handle and a narrow chisel-like blade at one end, and is very effective in disposing of weeds with thick roots, such as bull thistle, mullein and chicory. Many farmers have cleaned their farms of corn cockle, wild mustard, and many other weeds by a few hours of hand work each year when these weeds were in full blossom.

Spraying to prevent seeding. In case of certain weeds infesting small-grain crops, it has been found profitable to spray with a solution of copper sulphate, iron sulphate, or salt. If this treatment does not entirely kill the weeds, it at least prevents them from going to seed. Such treatment, if well done, does not permanently injure the grain, and is effective against the weeds. This method seems to be of most use against the wild mustard family of plants.

The spray solutions are made by dissolving either 12 pounds of copper sulphate, 100 pounds of iron sulphate, or 125 pounds of common salt in 50 gallons of water, which is sufficient to spray about 1 acre. Any machine that throws a fine mist-like spray may be used. Where areas of considerable

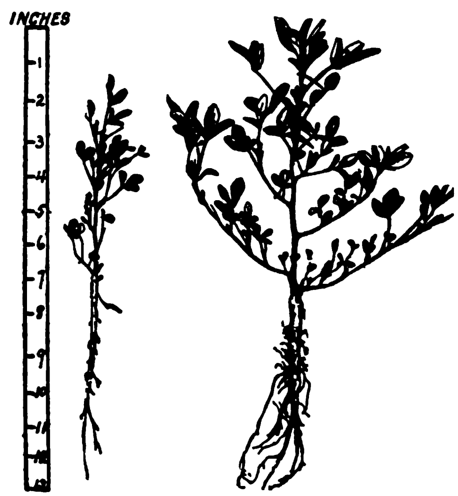


FIG. 596. The effect of weeds on white sweet clover. The plant at the left was sown two weeks ahead of the other, and, except for a heavy weed growth, conditions in the plot in which it grew were ideal. Four fifths of the plants in the weedy plot were killed outright. (Farmers' Bulletin 797.)

size are to be treated, a traction sprayer with a boom 12 to 20 feet long is the most economical equipment. In the case of wild mustard in small-grain fields, the best time to spray is when the most advanced of the mustard plants are just starting to bud.

Sheep pasturing to prevent seeding. Sheep are of use in preventing weeds from seeding. A pasture on which sheep are running is usually more nearly free of weeds than where cattle or horses are pasturing. In some parts of the United States, sheep are turned into standing corn after cultivation stops for the purpose of pasturing off the late weeds. Sheep turned on grain stubble tramp weed seeds into the soil, thus causing many of the seeds to germinate at once. The resulting plants are either pastured off or frozen out.

Burning to prevent seeding. Burning weeds is often useful in killing weed seeds, both in connection with weeds cut green and allowed to dry, and with matured weeds. It is sometimes necessary to gather such plants into piles before they will burn, but it is always best to disturb them as little as possible, so that the seeds will not scatter.

Preventing weed seeds from being brought to the farm. The second of the 3 main points in weed control is preventing the introduction of weed seeds on the farm. No matter how careful a man may be in preventing weeds from going to seed on his land, most of his work will be for nothing if he permits seeds to be constantly brought in from the outside.

Preventing the top growth of perennials. The last of the 3 weed preventive measures is keeping down the top growth of perennials in order to starve out the underground parts. This top growth is equivalent to the lungs of animals; without it they can not live. Any methods that successfully keep down the top growth and at the same time suit the farmer's convenience may be used. Among the practices that may be adopted are: (1) Clean cultivation; (2) pasturing; (3) growing smother crops; (4) frequent cutting and (5) smothering small patches with building paper or other material.

Special methods of handling certain weeds. The farmer should know the kind of weeds which he has to fight, because in the case of some of them, special methods have been discovered which greatly reduce the amount of work necessary. The United States Department of Agriculture has issued bulletins treating a number of the worst weeds, and these publications may be obtained on request.

Rotations and weeds. An important benefit from practising a rotation is the control of weeds. If land is planted to the same crop year after year, certain weeds have ample opportunity to make top growth, mature their seeds, and, become, therefore, firmly established; but if the land is planted to different crops in succession these weeds do not have the opportunity to make nearly as much headway. Furthermore, adopting a rotation usually means the growing of grass, clover, or other forage crops. These crops not only discourage many kinds of weeds by their shading effect, but also give weeds a poor chance to mature seeds, as they are cut for hay before most weeds ripen.

WHERE FOUND	HEIGHT FEET	SPECIAL FEATURES	BLOOMING SEASON	COMMON NAME	DESTRUCTIVE MEASURES A-annual, P-perennial
Grasses, Sedges and Reeds					
Everywhere. Bottom land and lawns.....	1-3..	Leafy, branched. Roots at joints.....	June—Oct.....	Crab or Finger grass........	A. Prevent seeding. Cultivate thoroughly
Everywhere. Uplands and lowlands.......	1-3..	Varies from stout and bristly to slender..	July—Oct......	Old Witch grass	A. Same treatment.
Everywhere. Cultivated fields esp.....	1-3..	Hardy, creeping stem	Aug.—Oct.....	Couch or Quack grass	P. Repeated diskings every 10 days from July 1.
Everywhere. River-banks, moist places.	½-2..	Forms "knees;" roots at lower joints...	June—Aug....	Marsh Foxtail..	P. Drain, cultivate, sow better grass.
East of Rockies. In valleys and in lawns.	½-2..	Very similar to Crab grass above	June—Sept....	Smooth Crab grass	A. Prevent seeding. Cultivate.
Eastern states, except extreme north	2-4..	Closely resembles millet.............	July—Sept.....	Barnyard grass	A. Cut often to prevent seeding.
East of Rockies and in California.........	1-3..	Bears clusters of burs	June—Oct.....	Sandbur, Bur grass	A. Burn and cultivate often.
All humid states. Low ground...........	.....	Triangular stems, nutlike tubers ...	Spreads by tubers.......	Northern Nut grass	P. Clean cultivation 2 years. Then heavy cropping.
Central and north-eastern states......	2-4..	In open ground, bogs and ditches......	Aug.—Oct.....	Rice Cut grass.	
All northern U. S......	1-2½.	Flowers in spikes...	July—Nov.....	Yellow Foxtail. Pigeon grass...	A. Burn over and cultivate.
Northern states. Chiefly cornfields...	1-3..	Many seeds. Forms tufts...........	July-Sept......	Green Foxtail..	A. Same.
Northern grain fields everywhere........	3-5..	Like oats, but seed is coarser........	June—Sept....	Wild Oats.....	A. Prevent reseeding.
In winter wheat, wherever grown.........	2-3..	Like oats, but smaller and darker.......	July—Aug......	Chess, Cheat...	A. Prevent seeding. Pull by hand.
West from Great Lakes Roadsides, pastures	½-2..	Purplish flowers; injures animal's mouths.	June—Aug. ...	Squirrel-tail grass........	A. Prevent seeding. Burn if possible.

WHERE FOUND	HEIGHT FEET	SPECIAL FEATURES	BLOOMING SEASON	COMMON NAME	DESTRUCTIVE MEASURES A–annual, P–perennial B–Biennial
South only. Usually escaped from meadows..............	1–4..	Valuable hay grass if controlled.....	All summer....	Johnson grass.	P. Cultivate and plant shading crops.
South only. In moist land..............	.....	Triangular stems...	Aug.—Nov....	Nut Sedge, Southern Nut grass........	P. Cultivate well 2 years, or crowd out with velvet beans.
Vines and creepers					
Everywhere. Field crops. Escaped from cultivation in South.	.....	Flowers 1 in. or less. Leaves round-tipped	July—Sept....	English Bind Weed Morning Glory........	P. Cultivate thoroughly and continuously. Apply salt.
Everywhere. Field crops. Escaped from cultivation in South.	.....	Flowers 2 in. or more	July—Sept....	Hedge Bind Weed.......	P. Late cultivation: easier to kill than preceding.
Everywhere. Field crops	.....	Large roots. Long leaves. Purple centred flowers.....	July—Sept....	Wild Potato, Manroot....	P. Grub out roots or pour on sulphuric acid.
Everywhere. Waste places and grain fields..............	2–4..	Greenish flowers....	June—Sept. ...	Wild Buckwheat Bind Weed....	A. Cultivation. Clean seed.
Gardens everywhere..	1–2..	Pink fleshy, radiating stems.......	June—Oct. ...	Pusley, Purslane	A. Hoe out and destroy.
Everywhere; parasite on herbs and shrubs.	.....	Suckers pierce host stems...........	June—Oct.....	Field Dodder..	A. Crop rotation and careful seed inspection.
Clover and alfalfa everywhere..........	.....	Brownish stems....	June—Oct.....	Clover or Alfalfa Dodder.....	A. Same as preceding.
Waste woods and shady spots..............	.....	Three-lobed leaf....		Poison Ivy....	P. Grub out and burn; avoid contact with vines or smoke.
Northern and western states. Hay fields and open places....	.....	Thorny. Spread by cattle, birds and root stalks.......	June—Sept....	Low Blackberry Dewberry..... Running Briar.	P. Crowd out by heavy seeding or cultivate thoroughly.
Weeds with prominent flowers or seeds					
Grainfields everywhere	.....	Flowers 1 in. reddish purple..........	June—Aug....	Corn Cockle...	A. Cultivation.
Fields and roadsides everywhere........	2–4..	Purple flowers, ½ in. Pods and silky seed	Aug.—Sept....	Milk Weed....	P. Prevent seeding, starve roots by frequent cutting.
Everywhere..........	.....	Small white flowers from whorl of leaves	May—Oct.....	Shepherd's Purse.......	A. Cultivation
Everywhere. Meadows and pastures.......	to 5...	Hairy stems. Flower white, yellow centre		Flea Bane daisy	A. Prevent seeding.
Everywhere. Roadsides and pastures......	1–3..	Racemes of flowers of two shades of yellow..........	July—Oct.....	Toadflax...... Butter and Eggs	P. Cut out often. Apply salt or sulphuric acid to roots.
Northern grainfields..	2–5..	Prickly; ½ in. yellow flowers..........	July—Sept.....	Black Mustard.	A. Prevent seeding. Spray with iron sulphate.
Northern grainfields ..	1–3..	Large flowers. Very common.........	June—Sept....	Charlock......	A. Clean seed. Mow often. Pull by hand.
Everywhere. Pastures and waste places....	1–3..	Smooth stem. Purple, erect flowers. Spreads by rootstocks	July—Sept.....	Thistle.......	P. Hoe off tops repeatedly. Apply salt, sulphuric acid or coal oil. Cultivate.
Winter grainfields everywhere..........	1–2..	Erect. Small yellow flowers. Brown sticky seeds......	June—Sept. ...	False flax......	A. Prevent seeding. Use clean seed.
Waste places, fields and gardens everywhere............	1–5..	Small white flowers in panicles.......	July—Sept.....	Horse Weed... Fleabane....	A. Pull up by roots before it seeds.
Everywhere. Escaped from old-fashioned gardens	1–2..	Heavy stems. Thick leaves, small purple flowers......		Live-for-ever...	P. Careful thorough cultivation.
Middlewest. Barnyards, cornfields, and waste places............	1–8..	Serrate leaves, greenish flowers. Rough appearance......		Marsh Elder...	A. Prevent seeding by cutting or cultivating.
Sandy fields everywhere............	½–1..	Rough, narrow leaves. Small white flowers.....	June—Sept....	Puccoon, Corn Gromwell....	A. Grow hoed crop and cultivate well.
Clearings and pastures everywhere.........	1–3..	Hairy, larger flowers than other thistle.		Bull thistle	P. Mow. Cut off below surface.
Neglected fields everywhere in North.....	1–3..	Coarse, purplish fls. Clinging burs....		Burdock.......	B. Prevent seeding.
Everywhere. Waste fields and roadsides .	1–3..	Coarse, rough, prickly bur, two hooks at one end.......	July—Oct......	Cocklebur.....	A. Prevent seeding.
Everywhere. Lawns and meadows......	½....	Rosettes of leaves. Yellow flowers...	April—Oct.....	Dandelion.....	P. Cut deeply. Apply sulphuric acid.

WHERE FOUND	HEIGHT FEET	SPECIAL FEATURES	BLOOMING SEASON	COMMON NAME	DESTRUCTIVE MEASURES A–annual, P–perennial, B–biennial.
Northeastern pastures and roadsides.....	½–1..	Fluffy seeds. Flat leaf clusters. Orange flowers.....	Spreads by runners.........	Devil's Paint Brush, Orange Hawk Weed.	P. Cultivate thoroughly or pasture with sheep.
Northern and Northwestern states.....	1–2..	Yellow and white ill-smelling daisy-like flowers......	June—Sept....	Dog Fennel....	A. Prevent seeding.
Central states North and South.........	1–3..	Spiny, bluish flowers, ½ in. berries......	Spreads rapidly by roots.....	Horse nettle...	P. Persistent cultivation.
Everywhere except West.............	½–4..	Large, purple flowers	Aug.—Sept....	Jimson Weed...	A. Prevent seeding.
Everywhere except South............	2–6..	Woody, dense spikes, yellow flowers....	July—Oct......	Great Mullein, Velvet Dock...	A. Cut out plants in fall.
Eastern meadows....	1–2..	Many, white-flowered head..........	June—Oct.....	Daisy.........	P. Mow or pull by hand if few. Otherwise put field in hoed crop.
Eastern and Middle states............	2–4..	Spiny leaves, yellow flowers..........	Spreads by rootstock.......	Sow Thistle....	P. Cut out with hoe or spade.
Northern states, gardens, and meadows..	2–5..	Small yellow flowers. Close clinging small burs............	Seeds carried by animals' coats	Beggar Tick, Sticktight...	A. Prevent seeding.
Northern and Eastern fields. Occasionally a cultivated crop....	2–4..	Rough brown, spreading, hairy plant. Large persistent burs.............		Teazel........	P. Cut or dig out.
Northern and Pacific states. Often in clover and alfalfa fields	Low.	Clover-like leaves Yellow flowers....		Black Medic...	B. Cultivate.
Meadows and pastures in Eastern and Central states.........	1–3..	Large, flat heads of white flowers.....		Wild Carrot...	B. Hoe or pull out. Destroy the fleshy, poisonous roots.
Northern and Pacific states............	1–4..	Small yellow flowers in umbels.......		Queen Anne's Lace Wild Parsnip	P. Prevent seeding.
Eastern and Central states. On limestone soils in fields and roadsides..........	1–4..	Much-branched, woody stems. Small yellow, fragrant flowers..........	June—Oct.....	Sweet Clover ..	B. Cultivate and crowd out by heavy cropping.
Lawns and gardens, Eastern and Central states..............	½....	Prostrate, branching, leafy. Small white flowers..........	April—Oct..... Spreads by runners..........	Chickweed.....	A. Cultivate and rake out.
Cultivated fields of Middle and Eastern states.............	2–4..	Velvety leaves; small yellow flowers, odd fruit............	July—Sept.....	Indian Mallow, Butter Print...	A. Pull up before flowering.
Roadsides and waste places east of Rocky Mountains.........	½....	Prostrate, hairy. Milky juice. Brown spotted leaves...	Aug.—Oct.....	Spotted Spurge	A. Prevent seeding. Burn over if necessary.
Weeds with small, not prominent flowers					
Everywhere.........	2–6..	Spiny leaves and stem. Milky juice. Small yellow flowers......	June—Oct.....	Prickly or Wild Lettuce.....	A. Cultivate, prevent seeding and burn over in spring.
Everywhere..........	1–3..	Finely cut leaves.	July—Oct......	Small Ragweed.	A. Mow while young.
Everywhere, Mississippi Valley especially............	1–4..	Flowers yellow. Hairy, erect. Young plants mealy; old ones smooth.	July—Oct.....	Lamb's Quarter, Goosefoot...	A. Prevent seeding; spray with iron sulphate 100 lbs to 1 barrel.
Everywhere. Roadsides, meadows and lawns............	2–6..	Coarse, large-rooted. Small-winged seeds		Dock.........	P. Pull out or cut root and apply carbolic acid, etc.
Everywhere..........	3–12.	Leaves and flower clusters 3-lobed.	July—Sept.....	Great Ragweed.	A. Cultivate and prevent seeding.
Everywhere. Bogs and marshy places.....	Creeping.	Branching trailer; roots at joints. Small pink flowers.	July—Sept.....	Smartweed....	P. Cultivate to prevent rooting. Prevent seeding.
Northern sections. Sandy soils in pastures and clover fields	½–1..	Spreading, resembling dock. Arrow-shaped leaf......	Spreads by creeping stem	Sorrel, Sheep sorrel.......	P. Crop land heavily and manure well to smother weed out.
Middle and Northwestern states. Wheat fields.............	½–1..	Broad-winged seeds. Erect stems, paired leaves..........	June—Oct.....	Pennycress....	A. Continuous cultivation. Use winter cover crop. Burn over in spring.
New York, Mississippi Valley and westward............	1–3½.	Ball form, fleshy leaves. Rolls across fields when dry...	July—Oct......	Russian thistle.	A. Mow and destroy before August.
Eastward from Iowa. Grain fields........	1–3..	Like garden onion. Fls. green or purple; small bulbils..	July—Sept....	Wild Onion or Garlic.....	P. Put field in hoed crop for 2 seasons.
Everywhere. Roadsides, waste places, pastures and dooryards............	.....	Flat rosette of leaves. Narrow, erect, many-seeded flower stalk......		Plantains.....	A. or P. Dig out and cultivate thoroughly.
Atlantic Coast from New Jersey to Texas	Low growing	Narrow leaves; flowers in axils......	June—Oct.....	Buttonweed, Alligator Head.	A. Prevent seeding and cultivate well.

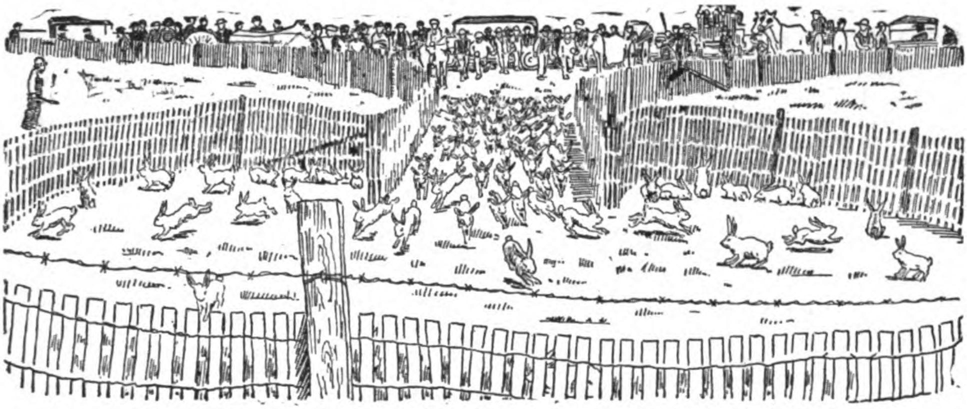


FIG. 597. The end of a rabbit drive in the Southwest

CHAPTER 36

Rodents and Other Animals That Injure Crops

By D. E. LANTZ, *late Assistant Biologist, U. S. Department of Agriculture, author of various bulletins on this subject, to which he has given many years of study and experiment. The number of kinds of animals and birds that injure or steal crops is relatively small—much smaller than that of the insect pests. Of the snakes all but 4 (rattlesnake, copperhead, water moccasin and coral snake) are exceedingly beneficial to the farmer; and except for 3 kinds of hawks, most birds are more his friends than his enemies. Indeed, with respect to all but the rodents discussed below, the general rule should be to destroy any individual animal found actually doing damage, but to avoid injuring all others. However, there will be plenty of opportunity for exercising ingenuity and effort if those mentioned below are to be successfully held in check or exterminated.*—EDITOR.

THE rodents, or gnawing mammals, of North and Middle America include nearly 1,400 species and geographic races recognized by naturalists. They belong to 77 distinct groups, called *genera* (each one a *genus*), of which 44 have representatives north of Mexico. Nearly 800 known forms inhabit the United States and Canada.* Many of them live in desert, mountain, or swamp, and rarely come in contact with cultivated crops. A few feed largely on insects instead of vegetation, some are valuable for their fur, and others afford sport and food; so that not nearly all are to be classed as noxious. However, no other order of mammals includes so many kinds that are harmful to property and crops. This is due not so much to their individual powers of destruction as to their remarkable fecundity and consequent abundance. The mouse, rat, and rabbit families are conspicuous examples of prolific breeding. The object of this short chapter is to acquaint the farmer or householder with the best available means for preventing loss from destructive rodents and for ridding his premises of the pests.

CHIPMUNKS. Both the eastern and western genera of chipmunks are occasionally plentiful enough to do serious damage to grain growing along the edges of fields. In the West they take garden seeds and sometimes enter stables or granaries to attack feed grain. They take conifer seeds planted by the foresters. Strychnine with oats is a

*Following an old but popular classification, we include rabbits and hares with the order of Rodents, but most modern naturalists place them in a separate order.

satisfactory poison when other grain is removed or protected (Formula 2, p. 534.)

GROUND SQUIRRELS. Most of the species of ground squirrels are injurious to crops, and in many parts of the West they take heavy toll of grain at planting time and before the harvest. Many of the species live in dense colonies and destroy whole fields of grain. When they are abundant, trapping

FIG. 598. A ground squirrel mound in an oat field, showing the damage it can do

has little effect on their numbers and poison alone will cope with them. Strychnine with oats or barley has proved the most satisfactory poison (Formula 1 or 2). For the larger forms of ground squirrels, use a smaller quantity of oats to each ounce of strychnine. Thus for a medium-sized or small species, 18 to 20 quarts to the ounce of poison is recommended; for the large Columbian species, only 12 or 13 quarts are required. Barley is usually recommended for the California or "digger" ground squirrel (1 ounce poison to 16 quarts of grain).

KANGAROO RATS. The two genera of Kangaroo rats differ mainly in the number of toes on the hind foot, and are alike in appearance and habits. They injure newly planted corn and gardens in sandy regions where they abound. When troublesome, they may be poisoned with oats and strychnine (Formula 1).

MICE. House mice. These common pests of the household often live in open fields and damage grain in shock and stack. Small snap traps lightly set and baited with oatmeal (rolled oats) will soon rid a house or pantry of the pests. When grain is present butter or toasted cheese is a good trap bait. For the open fields poisoned grain is recommended (Formula 3). For mice elsewhere the same methods apply as for poisoning rats.

Meadow mice. Meadow mice, known also as "bear mice" or "voles," sometimes become unusually abundant and cause great damage to crops. Nearly every winter they ruin orchards and other trees by girdling them under shelter of leaves, dead grass, or snow. Much of the injury may be prevented by clean cultivation and the removal of dead grass and litter in the fall. These mice are easily destroyed by poisoned grain put out under wide boards, brush, or piles of weeds (Formula 3).

Pine mice. Pine mice are closely related to meadow mice, but they tunnel underground like moles and attack trees below the surface, so that the injury is often unsuspected. When they invade garden, lawn, seedbed, or greenhouse in small numbers, they may be trapped with snap traps baited with dry oatmeal, as for house mice, or poisoned with oatmeal prepared according to Formula 9. For poisoning them on larger areas Formula 3 is recommended, or, better still, the sweet potato poison of Formula 4. Poison for pine mice should be dropped into their tunnels through holes made with a stick or those made by the mice themselves.

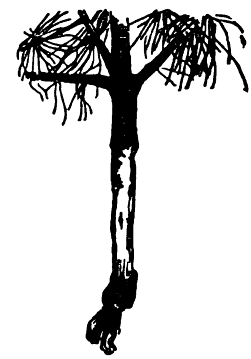


FIG. 599. Young pine tree killed by mice

Pocket mice. Except one species, these small mice of the Southwest do little harm. The injurious species is comparatively large and is found from Kansas to the Gulf Coast and westward. It destroys chiefly planted corn and garden seeds. It may be poisoned with oats and strychnine (Formula 1 or 9).

White-footed mice. These, also known as "deer mice," destroy planted seeds in fields and gardens, especially the seeds of melons and cantaloupes. Also, these mice are serious pests in nursery seedbeds, being particularly fond of the seeds of pine and other conifers. Poisoned oats (Formula 3) should be put out a week or more before planting seeds.

MUSKRAT. Since this is the most valuable fur animal left in the United States (10 to 12 million being caught every year, with a raw fur value of about $6,000,000) it should everywhere be protected, except where it interferes seriously with water power by weakening dams, etc. In such localities shooting is probably the best means of controlling it, although it may also be poisoned by sprinkling powdered strychnine on pieces of sweet apple. The muskrat sometimes injures gardens planted near the water where it may be held in check or, rather, kept outside the planted area by poultry wire fencing, the lower edge being sunk about 6 inches in the ground. The animal is found throughout the United States and Canada except along the South Atlantic Coast, and most

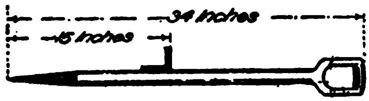


FIG. 600. Prod used in locating gopher tunnels

of the Gulf Coast, and in the interior deserts where there is no water.

POCKET GOPHERS. Pocket gophers, or pouched rats, occur in Florida, Alabama, Georgia, Illinois, and southern Wisconsin, while west of the Mississippi they are widely distributed from Texas to the Saskatchewan. They destroy all kinds of crops, especially clover and alfalfa, and ruin gardens and fruit trees. Their mounds interfere with the cutting of hay. They may be trapped with ordinary No. 1 steel traps, but much more successfully with the special gopher traps now on the market. The best plan is to use poison. (Formula 5.) Powdered strychnine sprinkled over freshly cut sweet potatoes is recommended as a bait. These are to be placed singly in the main tunnels of the gopher. An iron-pointed prod (Fig. 600) is used to make holes into the tunnel.

PORCUPINES. Porcupines are injurious to forest trees, mostly to conifers. No successful way of poisoning the animals is known. Shooting them has given the most satisfactory results.

PRAIRIE DOGS. Where they are abundant, prairie dogs consume so much grass and other vegetation that only about half the forage is left for range stock. They are destructive also to grain and other crops. The most effective means for destroying them is to scatter poisoned grain on hard ground near their burrows (Formula 1).

RABBITS. Cottontails. The smaller rabbits are destructive to gardens and young fruit trees. In many states they are protected as game, but in more than half of these the farmer is allowed to destroy the animals at any time on his own premises to protect property. In states that do not permit the killing of rabbits except in the open season, the only recourse of the farmer is to fence against them. Formula 1, recommended below for destroying jack rabbits can be used with equal success against cottontails. Box traps may also be used to advantage to trap them.

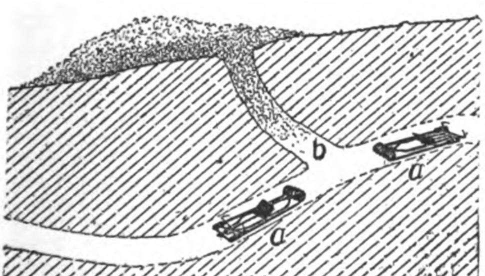


FIG. 601. Pocket gopher tunnels showing (*a*) where to put traps in relation to entrance run (*b*). (Cal. Bulletin 281)

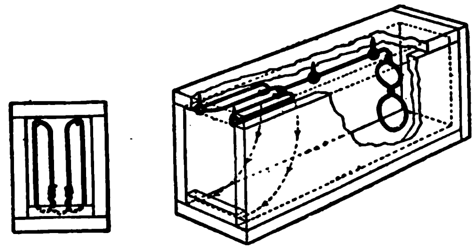


FIG. 602. Wellhouse rabbit trap viewed from the end and side to show simple construction. (Farmers' Bulletin 702.)

Jack rabbits. These large rabbits are common on the plains and in mountain valleys from Texas to Manitoba and from Kansas and Nebraska to the Pacific. They sometimes become exceedingly numerous and many are killed by "drives" or organized hunting. Their flesh becomes coarse and tough with age and they are not regarded highly as game. They injure all kinds of crops and in many places it is impossible to grow orchards without fencing out the rabbits or using protectors on the trees. Rabbits may be destroyed by the use of strychnine (Formula 1). Winter is the best time to poison them.

RATS. Cotton rats. These large native mice or rats are especially troublesome at times to newly planted corn and to shocked grains. Grain poisoned with strychnine, as for meadow mice, and put out in the spring or late fall will usually prove an efficient remedy (Formula 3 or 1).

House rats. Three kinds of house rats are found in North America—the brown rat, the black rat and the roof rat. The first, known

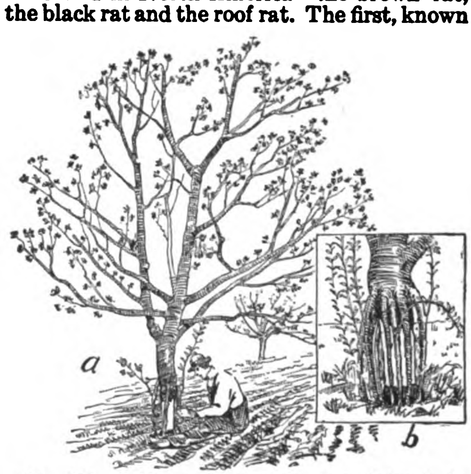


FIG. 603. Bridge-grafting apple tree injured by gnawing of rodents (a). Inset shows closer view of grafts in place over injured area.

also as barn, wharf, or Norway rat, is by far the most widely distributed and is the worst pest among all mammals, destroying each year more than all other rodents combined. Rats destroy crops in the open fields as well as in stacks and barns, and nearly all kinds of property are subject to their attacks.

To destroy rats in occupied dwellings strong snap traps, lightly set and baited with oatmeal, should be used. For fields, barns, warehouses, and storerooms, poison (Formula 6 or 7) will bring quicker results than traps. In the open fields or anywhere that rat burrows are accessible and go down into the ground, fumigation with carbon bisulphid is practicable (Formula 8). Little progress with traps or poisons is possible where rats have access to abundant food supplies; when these are removed or protected, success may be expected. Rat-proofing buildings and the elimination of hiding places for rats is the most important step in controlling them.

Wood rats. In the East wood rats usually live in the mountains and rarely damage crops. In parts of the West they sometimes live in hedges and do slight damage to grain, and in severe winters they occasionally gnaw the bark of trees. In the Far West they sometimes enter ranch houses and are very annoying to the inmates because they carry away all sorts of light property. They are often called "pack rats." They are easily trapped and may be poisoned like house rats.

TREE SQUIRRELS. The larger black, gray, and fox squirrels are not now very plentiful in agricultural regions, but they sometimes injure ripening corn or destroy fruit. They are protected as game in many states, but in some a provision of the law permits shooting them in closed season to protect property. Advantage of this permission should be taken only when it seems necessary to prevent serious loss. Trees standing alone are easily protected by placing tin or light metal collars, like an umbrella, about the trunk four or five feet from the ground.

The smaller red or "pine" squirrels do about the same kind of damage as the larger and they also are serious enemies of nesting birds. They are not usually protected by game laws.

FIG. 604. Break in an irrigation dam caused by the work of ground squirrels

WOODCHUCKS. Woodchucks are destructive to gardens and clover fields and their burrows interfere with mowing and cutting grain. The animals injure young fruit trees by biting them, but it is doubtful whether they actually consume the bark. Woodchucks may be poisoned by feeding them pieces of sweet apples or carrots in which strychnine has been inserted. They are easily trapped with ordinary No. 1 steel traps and may be destroyed in their burrows by the use of carbon bisulphid (Formula 8). If there are two or more entrances to a burrow, all but one should be closed before the carbon bisulphid is used.

Poison Formulas

1. Poison for prairie-dogs, the larger ground squirrels, jack rabbits, etc.

Mix thoroughly 1 ounce of powdered strychnine (alkaloid) and 1 ounce of common baking soda. Dissolve a heaping tablespoonful of laundry starch in a little cold water and add to ¾ pint of boiling water; boil and stir until the starch is clear. Slowly sift the mixture of strychnine and soda into the starch paste, stirring constantly to form a smooth, creamy mass. Add ¼ pint of heavy syrup and a tablespoonful of glycerine, and stir. Add $\frac{1}{10}$ ounce of saccharine, and stir once more. Pour this mixture while still hot over 13 quarts of clean oats in a metal tub, and stir until all the grain is coated. When the starch coat has dried, put out the poison, scattering it well for prairie dogs or squirrels.

2. Poison for medium-sized and smaller ground squirrels, kangaroo rats, etc.

Prepare as in Formula No. 1, but use 18 quarts of oats.

3. Dry-grain formula for meadow and pine mice, cotton rats, etc.

Mix thoroughly 1 ounce powdered strychnine, 1 ounce powdered bicarbonate of soda, and ⅛ ounce of saccharine. Put the mixture in a tin pepperbox and sift it gradually over 50 pounds of crushed wheat or 40 pounds of crushed oats in a metal tub, mixing the grain constantly so that the poison is evenly distributed. Put out in runs and, if possible, under shelter, using not more than a teaspoonful of the grain at a place.

4. Sweet potato formula for pine mice.

Cut sweet potatoes into pieces about as large as good-sized grapes. Place in a metal pan or tub and wet with water. Drain off the water and with a tin pepperbox slowly sift over them powdered strychnine (alkaloid preferred) mixed with the same bulk of powdered bicarbonate of soda. Stir constantly so that all the pieces of potato may receive some of the poison. An ounce of strychnine should poison a bushel of cut sweet potatoes. The baits are to be inserted, one at a place, in the mouse burrows.

PRINCIPAL INJURIOUS RODENTS OF AMERICA, NORTH OF MEXICO

COMMON AND GENERIC NAMES	NO. OF FORMS	DISTRIBUTION	INJURY DONE TO	HOW CONTROLLED
House Mouse (*Mus*)	1	Everywhere	Provisions, grains, textiles	Traps; poisons in fields.
House Rat (*Rattus*)	3	Most of United States; southern part of Canada.	Provisions, grains, textiles.	Rat-proof building, traps, poisons.
Cotton Rat (*Sigmodon*)	7	Gulf States; Kansas to Texas; Arizona.	Grain and vegetation.	Poison.
Wood Rat (*Neotoma*)	33	Widely distributed; only slightly harmful.	Grain and textiles in houses.	Poison and traps.
White-footed Mouse (*Peromyscus*)	71	Almost everywhere.	Seedbeds and gardens.	Poisons; traps in seedbeds.
Meadow Mouse (*Microtus*)	69	Almost everywhere.	Vegetation and trees.	Poisons.
Pine Mouse (*Pitymys*)	5	Middle of U. S.—Atlantic to Kansas.	Vegetation, gardens, trees.	Poisons.
Pocket Mouse (*Perognathus*)	48	Mostly in West and Southwest.	Grains (damage slight).	Poisons.
Pocket Gopher (*Geomys*)	16	Plains of West; Alabama, Georgia, Florida.	All crops; trees.	Poisons; traps in gardens.
Pocket Gopher (*Thomomys*)	61	Rocky Mountains to Pacific; northern plains.	Alfalfa, trees and all crops.	Poisons; traps in gardens.
Kangaroo Rat (*Perodipus*)	22	Sand hills and plains of West.	Planted seeds in field and garden.	Poisons.
Kangaroo Rat (*Dipodomys*)	17	Desert plains of Southwest.	do.	Poisons.
Tree squirrels (*Sciurus*)	39	Wooded areas everywhere	Corn, fruit.	Shooting. Tin collars on fruit trees.
Chipmunk (*Tamias*)	4	Wooded area, Atlantic to Minnesota.	Planted grain, seedbeds.	Poisons.
Chipmunk (*Eutamias*)	46	Foothills of Rocky Mountains to Pacific and northward.	Planted grain, seedbeds.	Poisons.
Ground Squirrels (*Citellus*)	57	Plains and valleys, Illinois to Pacific and far north.	All crops.	Poisons.
Prairie-Dog (*Cynomys*)	6	Kansas to Utah; Texas to Manitoba.	Grass; cultivated crops.	Poisons.
Woodchuck (*Marmota*)	13	Maine to Georgia; west to Kansas; also in western mountains	Trees (slight), gardens, clover.	Fumigation, traps, poisons.
Porcupine (*Erethizon*)	6	N. E. Woods; Canada; western mountains.	Trees.	Shooting.
Jack Rabbit (*Lepus*)	30	Western plains and mountain valleys.	All crops; trees.	Poisons.
Cottontail Rabbit (*Sylvilagus*)	31	Southern border to New York and southern Canada.	Trees, gardens.	Rabbit-proof fence; shooting, traps.

5. Poison for pocket gophers.

Cut sweet potatoes, carrots, or parsnips into pieces less than an inch in longest measurement. Wash and drain 8 quarts of the cut baits. Place them in a metal pan and from a pepperbox slowly sift over the dampened baits $\frac{1}{8}$ ounce of powdered strychnine (alkaloid) and one-tenth as much saccharine (well shaken together), stirring the baits to distribute the poison to all. See that each bait is placed in a main tunnel of the gopher and not in the lateral leading to a mound. One or two baits will be enough for each gopher working, as the animals are solitary in their habits.

6. Squill poison for rats and mice.

Chop a sea-leek fine and mix with flour and butter to make a thick dough; roll it out flat and dry in an oven. Pound into a fine powder which may be mixed with or used on any kind of suitable bait.

7. Barium carbonate for rats and mice.

Mix well 1 part of barium carbonate with 4 or 5 parts corn or oatmeal. Put out dry or mixed with bacon fat or butter.

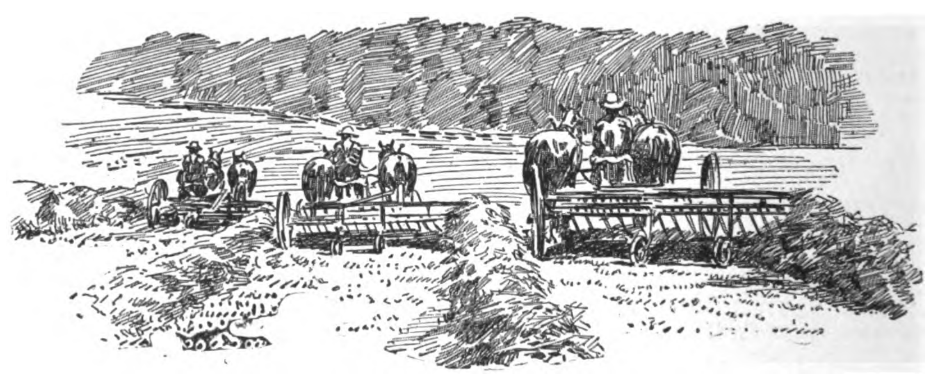
8. Carbon bisulphid for rats, woodchucks, or other rodents with simple burrows.

Pour a little carbon bisulphid ($\frac{1}{3}$ ounce for rat, 1 ounce for woodchuck) in a cup. With a long forceps dip a wad of cotton or waste big enough to take up all the liquid, into the cup, and put it well inside the mouth of the burrow. Cover the burrow tightly with a sod or other plug. Use this fumigation when the soil is damp, and be careful not to bring the liquid near a flame.

9. Poison for a few pine mice, or other rodents.

Dissolve half a bottle (one sixteenth ounce) of strychnine sulphate in a half pint of boiling water. Sweeten to a thick syrup. Mix it with as much oatmeal as the poisoned syrup will wet. Put out in mice runs or in entrance to burrows.

Caution. Care is necessary to prevent poisoned grains or other baits from being eaten by domestic animals or birds. Quail, grouse, and poultry are not easily poisoned by strychnine. The utensils used in mixing poison should be carefully washed, after which they may be safely used for any purpose.



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